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"The World, We Think She Start Over Again"
Nuclear Testing and the Marshall Islands, 1946-1958

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Chapter 1: The New World

At 8:15 a.m. local time on August 6, 1945, flying 30,000 feet over the city of Hiroshima, Major Thomas Ferebee, the bombardier of the B-29 bomber, Enola Gay, entered the target coordinates for Little Boy into the plane's automatic bombing computer. When the coordinates were reached, the computer released Little Boy, which exploded ninety seconds later 1800 feet over the city killing approximately 40,000 people and destroying much of the metropolitan area. Three days later, on August 9th, the bombing computer of a second B-29, Bock's Car,[1] released Fat Man over the city of Nagasaki producing the same results as Little Boy.[2] In the wake of the two bombings, Emperor Hirohito ordered a cessation of hostilities. In a prerecorded radio broadcast that a rogue army unit tried to destroy, Hirohito told his subjects that *"a new and most cruel bomb, the power of which to do damage is indeed incalculable"* is *"the reason why we have ordered the acceptance of the provisions of the Joint Declaration of the Allied Powers."*[3] Japan officially surrendered on September 2, 1945.[4] *"The atomic bombs that exploded over Hiroshima and Nagasaki,* historian Richard Rhodes has written, *"didn't win the war, but without*

[1] The name was a play on the last name of the plane's nominal pilot, Captain Frederick Bock.

[2] Nagasaki was the tertiary target. Weather conditions prevented target acquisition at the primary target, Kokura, and the secondary target, Niigata.

[3] Herbert Feis, *The Atomic Bomb and the End of World War II* (Princeton, N.J.: Princeton University Press), 248. The declaration is also known as the Potsdam Declaration.

[4] The formal peace treaty was not signed until September 8, 1951.

question they ended the war."[5] Historians Richard Hewlett and Oscar Anderson said the bombings created a *"New World"* in which nuclear weapons came to define and shape the foreign and military policies of the United States.[6]

Figure 1. Destruction caused by Little Boy. LANL Archives.

Fission

The explosive energy of Little Boy and Fat Man came from the splitting of more than a trillion trillion atoms in a microsecond. This splitting, known as fission, was accidentally achieved by Italian physicist Enrico Fermi, who, in 1934, bombarded Uranium with neutrons

[5] Richard Rhodes, "*A Different Country," Manhattan District Reunion* (Los Alamos: Los Alamos National Laboratory, 1993), 10; Lillian Hoddeson, et.al*, Critical Assembly: A Technical History of Los Alamos during the Oppenheimer Years, 1943-1975* (New York: Cambridge University Press, 1993), 13.

[6] Hewlett, Richard G. and Oscar E. Anderson. *The New World. A History of the United States Atomic Energy Commission, Volume I, 1939-1946*. (University Park: Pennsylvania State University Press, 1962; 1972); and Walter Millis, ed., *American Military Thought* (Indianapolis: The Bobbs-Merrill Co., Inc., 1966), xliv.

producing what looked like an array of elements. Fermi, however, did not comprehend what he had done. In 1938, two German chemists, Otto Hahn and Fritz Strassman, replicated Fermi's experiment achieving the same results, noting also that the mass of the elemental array did not equal that of the original atoms. Like, Fermi as well, Hahn and Strassman did not comprehend what they had done. Hahn wrote to a former colleague, Lise Meitner, describing the experimental findings.[7] Meitner and her nephew, Otto Frisch, deduced that Uranium atoms had been split into a myriad of elements and the "missing mass" converted into energy.[8]

Niels Bohr announced the discovery at the Fifth International Theoretical Physics Conference leading several physicists to repeat the experiment. Their results verified what had been discovered in Rome and Berlin.[9] At the same time, other physicists, particularly J. Robert Oppenheimer, immediately understood that energy liberated during fission could be used to create a bomb having extraordinary explosive power. Shortly after the Washington conference, a colleague entered Oppenheimer's office and saw a crude sketch of an atomic bomb drawn on the office blackboard.[10] Physicists Edward Teller, Eugene Wigner, and Leo Szilard took it upon themselves to alert President Roosevelt about the possibility of an atomic bomb. Their efforts ultimately led to the Manhattan Engineer District[11], whose single mission was to develop an atomic bomb.

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[7] Meitner, a Jew, had recently resigned her position at the Kaiser Wilhelm, fled Nazi Germany, and sought political asylum in Sweden.

[8] Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon and Schuster, 1995) provides a useful synopsis of the discovery of fission.

[9] The conference, held in Washington, D.C., attracted physicists from around the world.

[10] Robert Serber, "*Theoretical Studies at Berkeley*," reprinted in *Behind Tall Fences: Stories and Experiences about Los Alamos at the Beginning* (Los Alamos: Los Alamos Historical Society, 2003), 53-56.

[11] So named because the original headquarters of the District was located in Manhattan.

Los Alamos

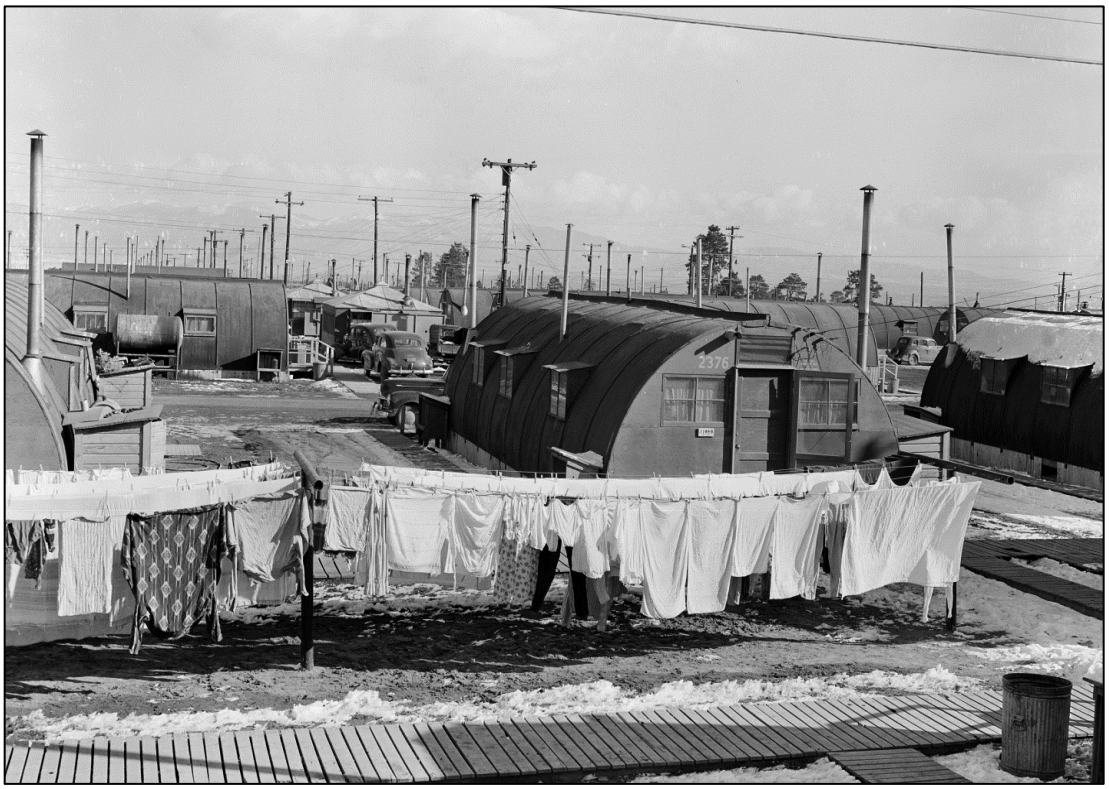

Figure 2. Typical housing and living conditions at Los Alamos. LANL Archives.

The MED created three principal facilities to accomplish its mission: Site X, a mammoth ^{235}U isotope production facility at Oak Ridge, Tennessee; Site W, an equally massive reactor facility at Hanford, Washington, to produce the isotope ^{239}Pu; and Site Y, at Los Alamos, New Mexico, to engineer both isotopes into atomic bombs.[12] Los Alamos, the site of an elite boarding school, was chosen for the security provided by its remote location high in the Jemez Mountains

[12] These isotopes are the fissile material in the first atomic bombs, known colloquially as "25" and "49" respectively.

of Northern New Mexico.[13] Construction of the Laboratory began in late 1942 and formal operations in April 1943 with an orientation seminar for the scientific staff.[14]

The seminar evaluated three possible weapon designs. The first and most promising design called for shooting a subcritical piece of nuclear material at a second subcritical piece of the same material thereby creating a supercritical mass and an explosion. This assembly method, known colloquially as the "gun," became Little Boy. The second possibility was to symmetrically crush a subcritical piece of nuclear material into supercritical mass. This assembly method, known as implosion, became Fat Man. The third possibility, an awkward autocatalytic assembly, received scant attention and was summarily dismissed. Oppenheimer focused the Laboratory's first year of operations on what was judged the best and quickest method, gun assembly. Within a year, however, two problems put the atomic bomb project in jeopardy. The first problem was the discovery that the Plutonium being sent to Los Alamos contained a contaminating isotope, ^{240}Pu. If Plutonium was used in a gun, this isotope would cause a premature, low order detonation. Gunpowder could not accelerate a projectile fast enough to overcome the influence of the ^{240}Pu. The second problem was a severe shortage of ^{235}U caused by production problems at Oak Ridge. Although Oppenheimer could do little about the situation

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[13] Lawrence Badash, J. O. Hirschfelder, and H. P. Broida, eds., *Reminisces of Los Alamos, 1943-1945* (New York: Springer, 1980).

[14] During the April 1943 classified technical meeting, a construction worker nearly fell through the ceiling of the building where the meeting was being held. Scientists and their families universally detested the newly built housing. Emilio Segre, one of many European scientists working at Los Alamos, and later a Nobel laureate, complained to housing officials about the overheating of his apartment saying on more than one occasion that *"the temperature of the walls in the apartment reached such a point that there was an obviously immediate danger of a fire."* On one such occasion, Segre ran to one of the few emergency telephones to place a call for help, but the phone didn't work. Segre later complained, *"The repetition of such occurrences and the precarious state of the alarm system on the Post makes me exceedingly uncomfortable, especially because having two small children at home. I don't feel safe leaving them alone even for a very short time."* The response was a desultory *"It is entirely possible that the telephone was out of order at the time you tried to call."* Laboratory buildings were somewhat better constructed, but only because the heavy machinery they housed required stouter structures. Office space was limited and very spartan even for Oppenheimer, who requested a nail to hang his coat and hat on. *Los Alamos Science*, *Number 7* (Los Alamos: Los Alamos National Laboratory, Winter/Spring 1983).

at Oak Ridge, he could refocus the Laboratory's technical work on implosion. The supersonic shock wave produced by tons of high explosives could implode a ball of Plutonium into a supercritical state quickly enough to mitigate the effect of the ^{240}Pu. In August 1944, Oppenheimer reorganized Los Alamos, placing primary emphasis on implosion. Oppenheimer also created a special group, known as the Cowpuncher Committee, *"to ride herd on implosion."*[15] These changes produced an implosion device ready for testing in July 1945. Believing that the ^{235}U production problems at Oak Ridge would be solved, Oppenheimer continued the gun program. He was correct, but not by much. Enough ^{235}U became available for one Little Boy.

Figure 3. Cabin where the isotopic impurity in Plutonium was discovered. LANL Archives.

[15] Cowpuncher Committee Records, LANL Archives.

Figure 4. Early implosion experiment during which a hollow pipe was crushed by high explosives. LANL Archives.

Trinity

The precision required by implosion required a proof of principle test, codenamed Trinity, that was scheduled for July.[16] The test was possible because of Oppenheimer's reorganization, and because Hanford was producing ^{239}Pu at a rate sufficient for both a proof test and at least one combat unit. However, ^{239}Pu remained scarce and extremely valuable and could not be wasted. If the Trinity failed, the material would be scattered across the landscape and lost. Hence, elaborate plans were developed for recovery of the ^{239}Pu in the event that the Trinity test failed. If a failure seemed probable, the Trinity device would be detonated inside a giant 216-ton containment vessel codenamed Jumbo.[17] Although an explosion would spatter the ^{239}Pu on the vessel walls, it could be recovered and reused. Shortly before the planned test, however, Hans

[16] Although Trinity was conducted primarily to prove that implosion (Fat Man) worked, the test also proved that fission could be engineered into an atomic bomb, making a test of Little Boy unnecessary – which was fortunate since only enough ^{235}U was available for one device.

[17] Leslie Groves, *Now It Can Be Told* (New York: Da Capo Press, 1962), 288. Jumbo had an inside diameter of 10 feet, was 25 feet long, with an overall thickness of 14 inches of steel.

Bethe assured Oppenheimer that Trinity would be successful, making Jumbo, suspended on end a quarter mile from ground zero, *"a silent partner."*[18]

Figure 5. Jumbo being prepared just prior to the Trinity test. LANL Archives.

In the early morning hours of July 16, 1945, Oppenheimer stood in the darkness of the southern New Mexico desert known as Jornada del Muerto, where he and hundreds of others

[18] K. E. Bainbridge to N. E. Bradbury, LANL Archives, July 11, 1945. Author's note: Fearing that the unused Jumbo, which had cost twenty million dollars, might attract unwanted attention from Congressional watchdogs, Major General Leslie Groves ordered Jumbo used for its intended purpose, the containment of an explosion. On April 16, 1946, Army ordnance personnel lowered eight 500-pound demolition charges to the bottom of Jumbo and detonated the charges at 11:30 am. Having been told that Jumbo was built to withstand a much greater explosive force than that of the eight demolition charges, the firing officer positioned himself only 600 feet from Jumbo. As that officer wrote of the explosion: "The foundation was pulverized and scattered over a large area. Both ends were torn off Jumbo and fragments were thrown as far as three-quarters of one mile. A piece, estimated to weigh over fifteen tons, landed 750 feet from the site. Jumbo now lies on its side in a crater which conceals all but a few feet of the unit which formerly stood some twenty feet high."

waited anxiously to see if their "gadget" would work.[19] Their anxiety was evident in the penultimate entry of the Trinity timetable, prepared by Norris Bradbury:

> ***"Sunday, 15 July, all day****. Look for rabbit's feet and four leafed clovers. Should we have the chaplain down there? Period for inspection available from 0900-1000."*[20]

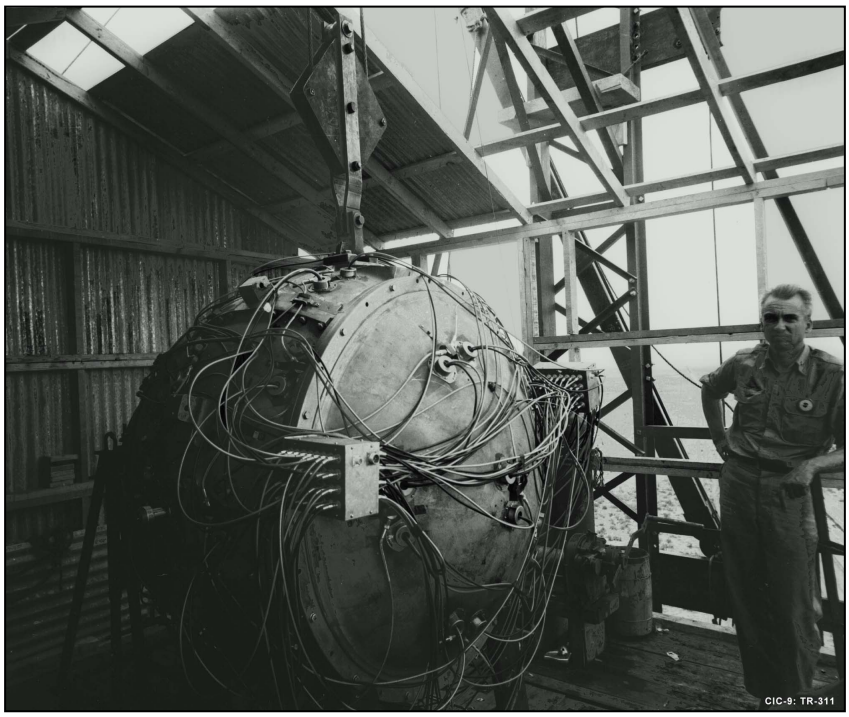

Figure 6. Norris Bradbury standing beside the Trinity device. LANL Archives.

At 5:45 am Mountain War Time,[21] just moments before the first rays of daylight appeared, the Trinity device exploded in a brilliant flash with the force of approximately 20 kilotons. Future Nobelist Richard Feynman took off his protective goggles and was temporarily blinded by the extreme brilliance of the explosion's fireball. Harvard chemist and Russian émigré, George

[19] Gadget was the generic code word used to describe the first atomic bombs. The name was also appropriate because the first two bombs, Little Boy and Fat Man, were not much more than laboratory gadgets.

[20] N. E. Bradbury to Concerned Personnel, *TR Hot Run*, LANL Archives, July 9, 1945.

[21] The equivalent of Daylight Savings time.

Kistiakowsky, wrote*, "the flash lit the countryside like a hundred suns and the reflection from the far away mountains nearly blinded me for a few seconds."*[22] Oppenheimer recalled a line from the Sanskrit poem, the Bhagavad Vita, *"I am become death, the destroyer of worlds."*[23] Test Director Kenneth Bainbridge said simply, *"Now we are all sons of bitches."*[24] Enrico Fermi, took out a piece of paper and tore it into small pieces. As the blast wave passed by him, he dropped the pieces of paper as a way of calculating Trinity's yield. As Fermi later wrote,

> *About 40 seconds after the explosion, the air blast reached me. I tried to estimate its strength by dropping from about six feet small pieces of paper before, during and after the passage of the blast wave. Since, at the time, there was no wind I could observe very distinctly and actually measure the displacement of the pieces of paper that were in the process of falling while the blast was passing. The shift was about 2½ meters, which, at the time, I estimated to correspond to the blast that would be produced by ten thousand tons of T.N.T.*[25]

Fermi underestimated the force of the blast by ten kilotons. Yet another Nobel laureate, I. I. Rabi, won the betting pool on Trinity's yield. Arriving late at the site, Rabi bought the last remaining number in the betting pool, 18 kilotons.

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[22] George Kistiakowsky, *Trinity – A Remembrance*, *Bulletin of Atomic Scientists*, June 1980, 19-22.

[23] J. Robert Oppenheimer, CBS Television Interview, 1954.

[24] K. E. Bainbridge, *LA-6300-H: Trinity* (Los Alamos: Los Alamos National Laboratory, 1946.)

[25] Enrico Fermi, *Eyewitness Account*, LANL Archives, July 1945.

Figure 7. Trinity at sixteen seconds after detonation. LANL Archives.

Figure 8. One of only six color photographs of Trinity. Color film was scarce and very hard to acquire. LANL Archives.

Figure 9. J. Robert Oppenheimer and General Leslie Groves at Trinity ground zero in October 1945. LANL Archives.

Although detonated in a remote part of New Mexico to help preserve secrecy, the magnitude of Trinity's blast and its extreme brilliance could not be absolutely hidden. Anticipating the event would be seen and heard, Groves hired *New York Times* Reporter William Laurence to prepare a press release announcing that an ammunition dump had accidentally exploded. This press release said, in part,

> *"Several inquiries have been received concerning a heavy explosion which occurred on the Alamogordo Air Base reservation this morning. A remotely located ammunition magazine containing a considerable amount of high explosives and pyrotechnics exploded. There was no loss of life or injury to anyone, and the property damage outside the explosives magazine itself was negligible."*[26]

[26] Leslie Groves, *Now It Can Be Told* (New York Da Capo Press), 301.

Twenty-one days later, on August 6th, Little Boy exploded over Hiroshima followed by Fat Man over Nagasaki on August 9th.

What Atomic Bomb?

At the instant Fat Man exploded in a blinding flash over Nagasaki, the United States had only one atomic bomb – or rather the unassembled components for one weapon. And, because the war ended soon after Nagasaki, there were no concrete plans to produce more. Having completed it's one and only mission, the MED became little more than a caretaker of the nation's diminished nuclear assets. Not until the Atomic Energy Act of 1946 converted the wartime nuclear program into a permanent civilian agency, did the nation begin to fashion its nuclear future. Over the following twelve years, the Atomic Energy Commission (AEC), working mostly through Los Alamos, built a nuclear complex including a stockpile numbering in the thousands. This stockpile was built on the data collected from 193 nuclear tests, sixty-six of which were conducted on less than five square miles of land on two Marshallese Atolls, Bikini and Enewetak. Among these sixty -six tests were the world's first hydrogen bomb, codenamed Mike (10.4 Megatons); the highest yield United States test, codenamed Bravo (15 Megatons); and the first production model hydrogen bomb, codenamed Cherokee (3.8 Megatons). These sixty-tests were fundamental to replacing the crude devices of World War II with weapons customized to meet military requirements. These tests, although technically significant, contaminated several Marshallese atolls and islands and created three Diasporas that remain today.

Chapter 2: The Marshall Islands

The Marshall Islands were accidentally discovered by the Spanish navigator Alvaro de Saavedra in 1529. The last of four navigators commissioned to claim the Spice Islands[27] for the Spanish crown, de Saavedra arrived in the islands only to find Portugal firmly in control.[28] With no hope of dislodging the Portuguese, de Saavedra set sail for Spain in late spring 1529, making landfall not long after at an outlying Marshallese Atoll, most likely Ujelang. Continuing on, he found a second outlying atoll, either Enewetak or Bikini. Finding no spices or other apparent natural resources, de Saavedra sailed on, dying shortly thereafter in the vast expanse of the Pacific. Having no value, Spain ignored the Marshalls, not even bothering to name them. They were considered *"nothing more than navigational hazards that were best avoided."*[29] Two hundred years later, the islands were named after British sea captain John Marshall.

The Missionaries, Germany, and Japan

The first sustained interest in the Marshall Islands came in 1855 when the American Board of Commissioners for Foreign Missions (ABCFM) established a formal mission on Ebon Atoll. Supported by the paramount Marshallese Iroij,[30] Kaibuki, the ABCFM *"came not only to save souls but to bring to the islanders such amenities of Western Civilization as clothing, schools, medical services – in effect their intention was to transplant 19th century New England*

[27] These are the Moluccas of Indonesia.

[28] An earlier Spanish expedition had been destroyed by Portugal. The Spanish survivors were living in a makeshift fort on the island of Tidore.

[29] Francis X. Hezel**,** *The First Taint of Civilization: A History of the Caroline and Marshall Islands in Pre-Colonial Days, 1521-1885* (Honolulu: The University of Hawaii Press), p. 34; Samuel Eliot Morrison, "*Historical Notes on the Gilbert and Marshall Islands," The American Neptune*, Volume IV, No. 2, 93; and Harold F. Nufer, *Micronesia Under American Rule, An Evaluation of the Strategic Trusteeship*, *1947-1977* (Hicksville, N.Y.: Exposition Press), 6.

[30] Marshallese for "chief."

folkways and mores as a whole to the Pacific."[31] The Marshallese took to Christianity and readily adopted modest western clothing, particularly Mother Hubbard dresses. Through missionary efforts, the Marshallese also quickly learned English, achieving a literacy level well above eighty per cent. In all things Christian, the Marshallese, particularly those on Bikini, proved an ideal population for the efforts of the ABCFM becoming in just fifteen years a self-supporting Christian population viewed by the American Board as *"a miracle of grace."* Missionary influence was soon threatened, however, when German traders began arriving in 1861 to harvest and export copra. The missionaries believed that German commercial efforts were the embodiment of the unpardonable sin of consumer greed. The traders, in turn, thought the missionaries were overly pious, constantly singing hymns, and collecting steep church taxes. However, their relationship proved symbiotic, because *"each yard of calico sold was another step along the road toward civilization."*[32] Traders realized a profit and missionaries a chaste dress code.

In 1885, at the instigation of the its traders, Germany, with the tacit approval of Great Britain, claimed the Marshall Islands as a colony. Spain, the nominal colonial administrator, protested, but was powerless to prevent the takeover. For the next twenty-nine years, Germany ruled the Marshall Islands with *"a no-nonsense approach to matters*.[33] By the eve of World War I, German interest in the Marshalls had all but evaporated because profits from copra exports did not cover the costs of governing the islands. Having no commercial or strategic value, Germany

[31] Robert C, Kiste, *Kili Island: A Study of the Relocation of the Ex-Bikini Marshallese* (Ph.D. Dissertation, Eugene Oregon: University of Oregon, 1968), 117; see also Jack A. Tobin, *Stories from the Marshall Islands* (Honolulu: University of Hawaii Press, 2002).

[32] Francis X. Hezel, *The First Taint of Civilization*, 255-256.

[33] Harold F. Nufer, *Micronesia Under American Rule*, 7.

completely abandoned the Marshall Islands, as it did all of its Pacific holdings, soon after World War I began. [34]

When Germany left the Pacific in 1914, the Japanese Navy occupied the Marshallese archipelago, establishing its administrative headquarters on Jaluit Atoll.[35] Japan continued its occupation throughout the war and into the first year of peace. When, under Article 22 of The Covenant of the League of Nations, Germany's colonies and territories were divided among the victors as mandates, Japan, not surprisingly, was assigned the Marshallese mandate. The Mandate system consisted of three classes that reflected a colony's level of political and economic development. The Marshall Islands were classified as Class C mandates, territories that, *"owing to the sparseness of their population or their small size, or their remoteness from the centers of civilizations … can best be governed under the laws of the Mandatory as integral portions of its territory."*[36] Under the mandate system, Japan was legally obligated to promote the material and moral well-being and social progress of the natives, to prohibit slavery and forced labor, to control traffic in arms, to exclude alcoholic beverages, to refrain from building fortifications and military bases, to permit freedom of worship and missionary activity, and to submit an annual report to the League.[37] Japan did so until it left the League in 1933. When Japan refused to return its Mandate, the League took no action despite the fact that the Marshalls

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[34] Peter Overlack, "*German War Plans in the Pacific, 1900-1914,*" *Historian 60, no. 3* (1998): 578-593. For the impact of the Japanese see Qinzhi Chen, Mark R. Peattie, Ramon Hawley Myers *The Japanese Colonial Empire, 1895-1945* (Princeton, N.J.: Princeton University Press, 1984); Mark R. Peattie, *Nanyō: The Rise and Fall of the Japanese in Micronesia, 1885-1945* (Honolulu: University of Hawaii Press, 1988), 14.

[35] Peter Overlack, "*German War Plans in the Pacific, 1900-1914,*" *Historian 60, no. 3* (1998): 578-593. For the impact of the Japanese see Qinzhi Chen, Mark R. Peattie, Ramon Hawley Myers *The Japanese Colonial Empire, 1895-1945* (Princeton, N.J.: Princeton University Press, 1984).

[36] Francis X. Hezel, *Strangers in their Own Land: A Century of Colonial Rule in the Caroline and Marshall Islands* (Honolulu: The University of Hawaii Press), 155. Japan received the South Pacific Mandate, which included the Mariana, Caroline, and Palau island groups in addition to the Marshalls.

[37] Robert C, Kiste, *Kili Island: A Study of the Relocation of the Ex-Bikini Marshallese*, 112.

remained the legal responsibility of the world body. This rather complicated fact of international law had to be resolved by the League's successor, the United Nations, after World War II.

Plan Orange

In 1906, Rear Admiral Raymond P. Rodgers, President of the Naval War College, authored an informal study of a possible war with Japan. In particular Rodgers anticipated that Japan would invade and occupy the Philippines, where the United States had extensive military facilities. In 1924, the United States Joint Army and Navy Board used Admiral Rodgers' study as the foundation for War Plan Orange, which called for the U.S. Navy to sail from its west coast ports (later Pearl Harbor) and engage the Japanese in the Philippines. However, modern, long-range aircraft, flying from Pacific island bases, including the Marshalls, stood between Pearl Harbor and the Philippines. [38] Having to abandon the Philippines in the short run, the Navy began its campaign against Japan by way of "island hopping," invading and capturing only those islands having strategic value.[39] This campaign began with the invasions of three Marshallese atolls – Majuro, Kwajalein, and Enewetak. Majuro, abandoned early in the war by Japan, was occupied by the United States on January 31, 1944, and quickly turned into a major supply base and rest camp.[40] Kwajalein, also invaded on January 31st, was the scene of vicious and bitter fighting beginning when troops of the United States Marines Corps invaded the atoll's two northernmost islands, Roi and Namur. Roi fell to the Marines on February 1st. Namur, connected to Roi by a causeway, did not fall until February 2nd. Also, on January 31st, Army troops invaded

[38] Allen R. Millett and Peter Maslowski, *For the Common Defense: A Military History of the United States of America* (New York: The Free Press. 1994.), 381.; https://en.wikipedia.org/wiki/War_Plan_Orange

[39] Robert D. Heinl and John Crown, *The Marshalls: Increasing the Tempo* (Washington, D.C.: United States Government Printing Office, 1954). The Combined Chiefs of Staff were the collective service chiefs of both the United States and Great Britain.

[40] One of Majuro's islands became a major rest camp for submarine crews.

the atoll's main island of Kwajalein, located at the southern extreme of the atoll.[41] Kwajalein Island, with its relatively large land mass and a large number of Japanese defenders, did not fall until February 7th. Enewetak Atoll was invaded on February 17, 1944, beginning with the amphibious assault by United States Marines of the atoll's northernmost island, Engebi, which was captured six hours after the first troops waded ashore. Enewetak Island, 800 yards wide and a mile long, took three days to capture. Parry Island, immediately adjacent to Enewetak, took two days. The battle for Enewetak took 339 Marine and 2,677 Japanese lives. Only 64 Japanese prisoners were taken. No one counted the number of Marshallese casualties.[42] Other atolls, including Bikini, were taken with almost no effort. The small boatload of Marines assigned to assault Bikini landed only to find the five Japanese stationed on the island dead by their own hands. The Japanese strongholds on Jaluit, Maloelap, and Wotho were bypassed, becoming training targets for new US bomber crews.

Immediately after combat operations ceased in the Marshalls, Admiral Chester Nimitz issued Proclamation Number One, which established military governance of the islands:

> *"All powers of government and jurisdiction in the occupied territory and over the inhabitants therein, and final administrative responsibility, are vested in me as Admiral, United States Navy, commanding the United States Forces of Occupation, and Military Governor, and will be exercised through subordinate commanders by my direction. [It is the policy of United States Forces] not to make war upon the civilian inhabitants or these islands but to permit them to continue their normal lives and occupations in a peaceable manner, so far as war necessities and their own behavior permit."*[43]

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[41] Many Marshallese atolls, including Kwajalein and Enewetak, also have islands with the same name.

[42] Robert D. Heinl, "*D-Day, Roi-Namur." Military Affairs: The Journal of the American Military Institute 12, no. 3* (1948): 129-141; Morison, Samuel Eliot. *History of United States Naval Operations in World War II*; Charles Corlett, *Cowboy Pete*; and Philip Crowl, Philip Axtell, and Edmund G. Love, *Seizure of the Gilberts and Marshalls (United States Army in World War II: The War in the Pacific*. Washington, D.C.: Center of Military History, Dept. of the Army, 1989).

[43] Ibid, 245.

While the proclamation was a legal requirement, it had little impact or meaning. The Marshallese people had not exercised any substantial form of self-rule, or any form of civil disobedience since the arrival of the first missionaries in the middle of the 19th Century. As Dorothy Richard pointed out in her study of Navy administration of the Pacific, *"The friendliness of the Marshallese people toward the American military forces was due in no small measure to the respect and affection with which American Protestant missionaries had been held for almost a century in the islands."*[44] One of the most important outcomes of the early months of American occupation, a *National Geographic* correspondent reported, was improved sanitation and the elimination of massive fly populations. The American military was seen as the savior of the Marshallese people. Having endured privation and starvation at the hands of the Japanese, the Marshallese people as a whole were very happy to be liberated by American troops.[45]

United States military governance, while beneficial for the most part, did set the stage for the eventual displacement of the Enewetak peoples from their atoll. After capturing Enewetak, the Navy began using the atoll as a staging area for fleet operations. To avoid conflicts with the native islanders, the Navy moved the atoll's inhabitants to the remote northern island of Aoman. thereby co-mingling the two native tribes of the atoll: the dri-Engebi people of the northern half of the atoll and the dri-Enewetak people of the southern half. This relocation created a jurisdictional problem because Aoman was nominally governed by the Iroij of Engebi. The issue was temporarily settled when the dri-Enewetak tribe waded to an adjacent island, Bijiri.[46] A

[44] Ibid, 400

[45] W. Robert Moore, *"Our New Military Wards, The Marshalls," The National Geographic Magazine*, Volume LXXXVII, Number Three, September 1945, 360.

[46] The term "dri" means "people of." Engebi and Enewetak islands are the ancestral homes of these two tribes.

second relocation in 1948 to Ujelang Atoll once again co-located the two tribes, this time permanently.[47]

Strategic Trusteeship

American combat sacrifices in the Pacific immediately raised the question of whether or not, after the war, the United States could give up the islands that had claimed the lives of so many Marines, sailors, and soldiers. The answer, for the Joint Chiefs of Staff, was no. The United States had the right to govern, they believed, *"as it deemed necessary because of its hard fought and bloody victories."*[48] The JCS remained firm in its belief *"that no forces under their control would take any action, make any plans, agreements or statements which directly or by implication might serve as a basis for any nation other than United States from obtaining sovereignty or any other territorial rights therein."*[49] The Chief of Naval Operations, Admiral Ernest King, and the Commanding General of the Army Air Corps, H. H. Arnold, said the Marshall Islands were important to the future security of the United States and should remain in American hands. *"The future peace of the world,"* they said, *"indeed, the fate of mankind may depend on it."*[50] The State Department objected to the JCS position on legal grounds saying that a political solution had to be crafted because the United States was a member of the Principal Allied and Associated Powers, the temporary wartime successor to the League, which held title to the Marshall Islands. If the United States was to retain control of the Marshall Islands, it had to be through the League's permanent successor, the United Nations.

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[47] Harold F. Nufer, *Micronesia Under American Rule*, 7.

[48] Hal M. Friedman, *Arguing Over the American Lake: Bureaucracy and Rivalry in the U.S., 1945-1947* (College Station, Texas: Texas A&M Press), 1.

[49] Dorothy Richard, *United States Naval Administration of the Trust Territory of the Pacific Islands,* 164.

[50] W. Robert Moore, *"Our New Military Wards, The Marshalls,"* 360.

Subsequently, the United Nations replaced the Mandate system with one of Trusteeships. Seeking to solidify its control of the Marshalls, the United States successfully argued for a special designation known as a "strategic trusteeship," which gave it unilateral control over the islands and made possible the conversion of Bikini and Enewetak Atolls into the Pacific Proving Grounds. The strategic trusteeship also gave the United States political cover, allowing it to control the Marshall Islands as a colonial possession without the onus of being labeled a hypocritical imperial power. Strategic Trusteeship was *"annexation in all but name."* The United States could *"have its cake and eat it too."*[51]

When, in 1954, the Marshallese people protested the use of their homeland for nuclear testing, their vehicle of dissent, somewhat ironically, was the strategic trusteeship, which gave them direct access to the United Nations. Their petition stated in part:

> *The following should not be misconstrued as a repudiation of the United States as governing agency for the United Nations under the trusteeship agreement, for aside from the complaint registered in this petition we have found the American administration by far the most agreeable one in our memory. But in view of the increasing danger from the experiments with deadly explosives thousands of times more powerful than anything previously known to men, the lethal effects of which have already touched the inhabitants of two of the atolls in the Marshalls, namely Rongelap and Utirik, who are now suffering in various degrees for "lowering of blood count," burns, nausea and the falling of hair from the head, and whose complete recovery no one can promise with any certainty, we, the Marshallese people feel that we must follow the dictates of our consciences to bring forth this urgent plea to the United Nations, which has pledged itself to safeguard the life, liberty and the general well-being of the people of the Trust Territory, of which the Marshallese are a part.*

The United States' response, signed by Secretary of State John Foster Dulles, said, in part:

> *The United States Government, and the officers immediately concerned with the administration of the territory, greatly appreciate the words of commendation of the petitioners with respect to the way the territory is being administered. The*

[51] Friedman, 204.

> *welfare of the inhabitants has been the constant concern of the Government, and particularly of the High Commissioner, who will continue to spare no effort necessary to give effect to the trusteeship agreement.*[52]

Dulles' response was disingenuous on two counts. First, the welfare of the Marshallese was never rigorously pursued and, second, because the Trust High Commissioner had very little influence over the AEC and its test program. Although the Marshallese petition did not have the desired outcome, it did set the stage for continued political agitation by the Marshall Islanders as well as that of other countries, such as Japan and India, that brought about the 1958 moratorium and the end of testing in the islands.[53]

Facing continuing and increasing criticism of its control of the Marshall Islands, particularly as the last of the postwar trusteeships were being abrogated, the United States did not object when, in 1979, the Marshallese wrote and approved a constitution that inaugurated self-government. On June 23, 1983, the Marshall Islands and the United States signed a Compact of Free Association. Under the Compact, the Republic of the Marshall Islands and the United States agreed to remain connected both politically and economically. The United States made the new Republic part of its postal and telephone networks, and the dollar remained the official currency. As part of the Compact, the United States also negotiated the continued use of Kwajalein's massive lagoon as a missile impact area.[54] In 1986 the United States unilaterally and formally declared an end of its United Nations Strategic Trusteeship. The UN formally agreed in 1990.[55]

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[52] *Complaint Regarding the explosion of Lethal Weapons within our Home Islands.* Author's copy.

[53] By the end of the decade both the State Department and Dulles had changed their minds and withdrew their support for any future testing in the Marshall Islands.

[54] Ibid.

[55] http://unicover.com/OPUBA565.htm.; *The Washington Post Times Herald*, May 26, 1961; and *The Washington Post*, May 18, 1990.

Chapter 3: Bomb Away

The United States Army Air Corps' B-29 Bomber Dave's Dream, carrying a Fat Man atomic bomb christened Gilda, rotated off the Marshallese island of Kwajalein at 5:55 am local time on June 30, 1946, headed for Bikini Atoll.[56] As soon as the large bomber safely cleared the Kwajalein's runway, Leon Smith, a Los Alamos electronics expert, crawled into the bomb bay and activated Gilda's firing circuits. Smith completed his task just before Dave's Dream climbed through 10,000 feet.[57] From an altitude of 30,000 feet over Bikini's lagoon, the bombing computer of Dave's Dream released Gilda over an array of obsolete Japanese and American warships, as well as the sole surviving capital ship of the German battle fleet, the Prinz Eugen.[58] The bombardier's aiming point was the huge United States battleship Nevada, whose superstructure had been painted red to aid the bombardier in target acquisition. Gilda detonated, as planned, 550 feet over Bikini's lagoon, but missed the Nevada by one-half mile.[59] Since the fleet of target ships had been precisely anchored around the Nevada to maximize damage, the miss significantly reduced Gilda's effect. Nonetheless, Gilda sank five ships, severely damaged eight others, and exposed a large number of pigs, goats, and rats to lethal doses of ionizing radiation. Visually, Gilda did not appear all that impressive to observers. As reporter William Laurence recalled, *"To some of the newspaper men aboard, keyed up to the point of expecting the observer ship to be blown out of the water, the spectacle, obscured somewhat by an*

[56] The bomber was named after Captain David Semple, who was killed in a crash during the bombing competition held to determine which plane and crew would participate in Operation Crossroads. Semple was also the test pilot assigned to Los Alamos during World War II. Gilda was the popular name given to the bomb expended during Test Able. The second Bikini bomb was christened Helen of Bikini and was expended during Test Baker.

[57] Leon Smith, personal communication, 2010. Smith needed to vacate the unpressured bomb bay at 10,000 feet, above which he would have suffocated.

[58] https://en.wikipedia.org/wiki/German_cruiser_Prinz_Eugen.

[59] Although the cause of the bombing miss was never established, Fat Man did have terrible aerodynamic properties that were well known.

intervening white cloud, was a disappointment. To me, who could distinguish between the natural cloud and the atomic cloud, the sight was awesome and spine chilling."[60] Unlike the very visible carnage caused at Hiroshima and Nagasaki, much of the destruction caused by Gilda simply vanished underwater. Bikini's islands were undamaged.

Figure 10. Leon Smith in flight gear. LANL Archives.

[60] William Laurence, *Dawn over Zero: The Story of the Atomic Bomb* (New York: A. A. Knopf, 1946), 275. Laurence also had been an observer at the Trinity test in July 1945 and flew on the Nagasaki strike mission.

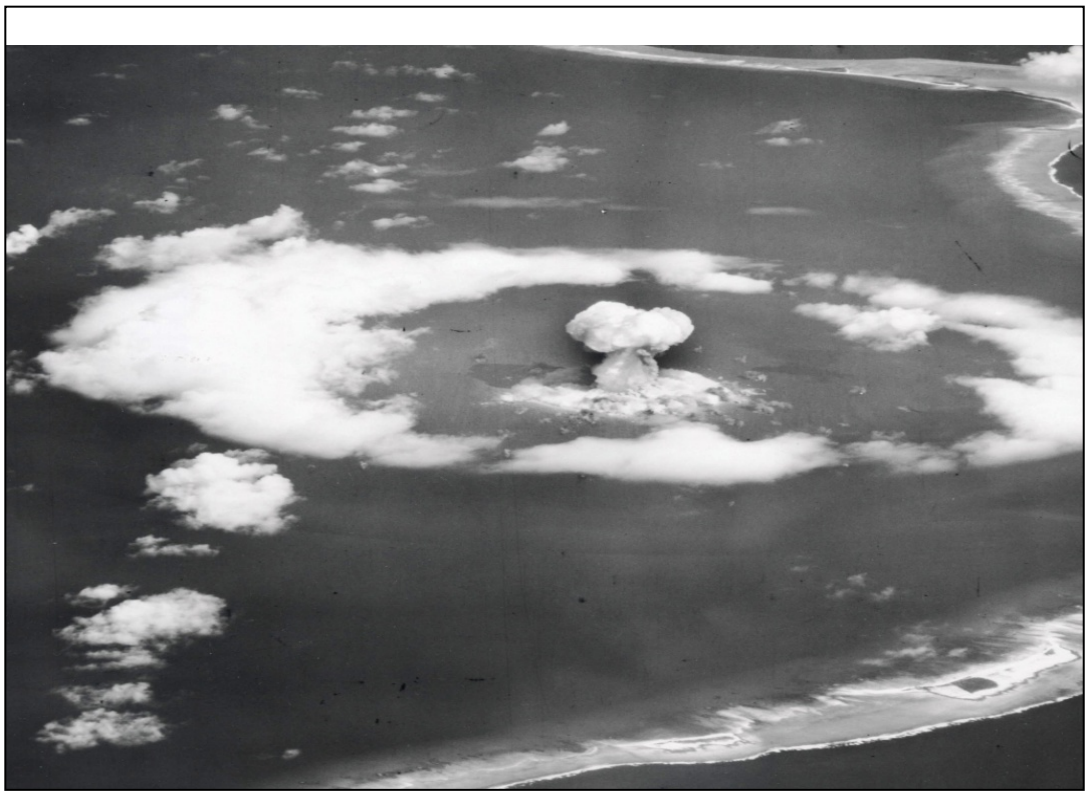

Figure 11. Gilda. LANL Archives.

Figure 12. Damage to the USS Nevada from a miss of one half mile. LANL Archives.

Crossroads - Origins

The massive devastation caused by Little Boy and Fat Man caught and held the attention of United States Senator James O'Brien McMahon, (D-CT), who proposed using the atomic bomb against what remained of the Japanese battle fleet. In a speech before his Senate colleagues, McMahon said,

> *"In order to test the destructive powers of the atomic bomb against naval vessels, I would like to see these [Japanese naval] ships taken to sea and an atomic bomb dropped on them. The resulting explosion should prove to us just how effective the atomic bomb is when used against the giant naval ships."*[61]

McMahon's proposal, which had as a precedent the experimental bombing of the captured World War I German battleship Ostfriedland, led to the first peacetime tests of atomic weapons, known as Operation Crossroads.

In response to this interest, the JCS created a planning group under Commodore William Parsons. During the war, Parsons served at Los Alamos and received the Silver Star for personally arming Little Boy on the flight to Hiroshima.[62] Parsons enlisted a former Los Alamos colleague, émigré Hungarian mathematician John von Neumann, to estimate and characterize the effects of an underwater nuclear burst on steel ships.[63] Von Neumann reported that not only would submersed atomic bombs be effective, they could, under certain circumstances, sink a

[61] Joint Task Force One, *Technical Report of Operation Crossroads* (Washington, D.C.: Joint Task Force One, 1946).

[62] As a Navy Captain, Parsons was assigned to Los Alamos in 1943 to engineer Little Boy and Fat Man into true combat weapons. Although very successful in this task, Parsons paid a heavy professional price. Since he did not have a combat sea command, he was denied the normal promotion to Rear Admiral – being promoted instead to the rank of Commodore, a long-abandoned rank that was temporarily reinstated during war for such commands as harbor masters.

[63] Along with Edward Teller, Eugene Wigner, and Leo Szilard, Von Neumann was one of four Hungarian emigrants to work on atomic energy matters during World War II. They were collectively known as the Martians because of their "otherworldly" intelligence.

capital ship up to a distance of one-half mile from the point of detonation.[64] Based on von Neumann's study, Parsons and his group recommended an above water test with a bomb suspended from a blimp, a deep-water test with a bomb suspended one-half mile beneath the surface, a shallow water test in a harbor, and an aerial drop by a B-29 bomber. Recognizing that radioactive fallout had to be mitigated, the group recommended Ulithi Atoll in the western Caroline Islands of Micronesia where, among other factors, removing the natives *"would not be a major problem."*[65]

In early January 1946 President Truman authorized the JCS to carry out Crossroads. The JCS approved three of the four proposed tests and assigned executive responsibility for the operation to Admiral Chester Nimitz, the Chief of Naval Operations.[66] Nimitz, in turn, created Joint Task Force One (JTF-1) under the command of Admiral William "Spike" Blandy to plan and carry the tests.

It fell to Blandy to select a test site based on nine specific requirements:

- *A protected anchorage at least six miles in diameter to accommodate both a large fleet of target ships as well as the JTF-1 support fleet.*
- *An unpopulated region situated at least 300 miles from urban areas - to prevent any possible exposures to the United States.*
- *A location less than 1000 miles from a B-29 base, since at least one bomb would be an airdrop.*

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[64] Roger A. Meade, "*Bikini Atoll: Operations Crossroads*," *Nuclear Weapons Journal*, *No. 4*, (Los Alamos: Los Alamos National Laboratory, 2003), 21.

[65] W. S. Parsons to N. E. Bradbury, *Possible Tests of Atomic Bombs Against Naval Vessels*, LANL Archives, October 16, 1945. Anticipating local fallout from Trinity, monitoring stations were placed in the surrounding towns and villages. When none of these communities received measurable fallout, Oppenheimer and others believed that Trinity's fallout was localized near ground zero. But, other surprising data soon surfaced that forced a different conclusion. When unusually large amounts of defective photographic film were returned to Kodak, an investigation revealed that wheat straw harvested in Indiana and used in the construction of packing boxes sold to Kodak had been contaminated by fallout from Trinity. While Los Alamos scientists knew that wind currents would carry fallout, they were quite surprised that it traveled so far. This discovery influenced planning for Operation Crossroads, including the selection of Bikini and Enewetak Atolls.

[66] The blimp shot was eliminated.

- *Predictable wind patterns directionally uniform at all altitudes from sea level to 60,000 feet to insure a safe dispersal of radioactive debris.*

- *Predictable ocean currents of great lateral and vertical dispersion and avoiding fishing areas, steamer lanes, and inhabited shores, again to insure the safe dispersal of radioactive debris.*

- *Minimum distance from continental United States, once again, to prevent any exposures to United States citizens and to facilitate logistics.*

- *Owned and controlled by the United States to insure uninterrupted operations.*

- *Temperate or tropical climate that could accommodate outdoor operations.*[67]

Blandy eliminated Ulithi from consideration because of the atoll's very small islands and its extreme distance from the continental United States. Looking elsewhere, Blandy settled on Bikini Atoll, significantly closer to the continental United States with a large lagoon and sufficient land mass to accommodate numerous instrumentation stations. Bikini, like Ulithi, also had a very small population that could be relocated without much thought or effort.[68]

Los Alamos

Despite presidential approval, the creation of JTF-1, and the selection of Bikini, there were no atomic bombs. The nation's entire stockpile of nuclear weapons consisted, as it did immediately after Nagasaki, of one unassembled Fat Man. Postwar demobilization, particularly staff departures at Los Alamos, meant that producing new bombs would be a major, if not prohibitive undertaking. In December 1945, the Laboratory's Technical Board and Weapons Panel discussed Crossroads with *"considerable pessimism."*[69] Los Alamos Director Norris

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[67] Joint Task Force One, *Technical Report of Operation Crossroads* (Washington, D. C.: Joint Task Force-1, 1946), 1.7 – 1.8.

[68] Dorothy E. Richard, *United States Naval Administration of the Trust Territory of the Pacific Islands, Volume 1* (Washington, D.C.: Office of the Chief of Naval Operations, 1957), 126 and W. A. Shurcliff, *Technical Report of Operation Crossroads* (Washington, D.C.: Task Force One, 1945), 1-3; and Jonathan Weisgall, *Operation Crossroads*, 31-33.

[69] *Summary of Technical Board and Weapons Panel Meeting held 6 December 1945*, LANL Archives. It was Los Alamos' operating procedure, begun during the war, to have technical committees review all Laboratory work.

Bradbury told Groves, *"At the present rate of loss of personnel, the predicted naval tests[70] will be barely possible in early summer, 1946, and definitively impossible after the first of September 1946."* Bradbury went on to say, *"Without effective and early Congressional action [on atomic energy legislation], I am seriously concerned that the Los Alamos Project may be quite unable to provide the technical assistance which these navel tests deserve and require."*[71] Navy Captain Ralph Larkin, the ranking military officer at Los Alamos, told Groves in late August that the scientists who remained felt ignored and frustrated and that *"University positions are very much in the foreground and decisions are being reached every day on definite commitments."*[72] Los Alamos, with great effort, managed to produce Gilda and Helen of Bikini.

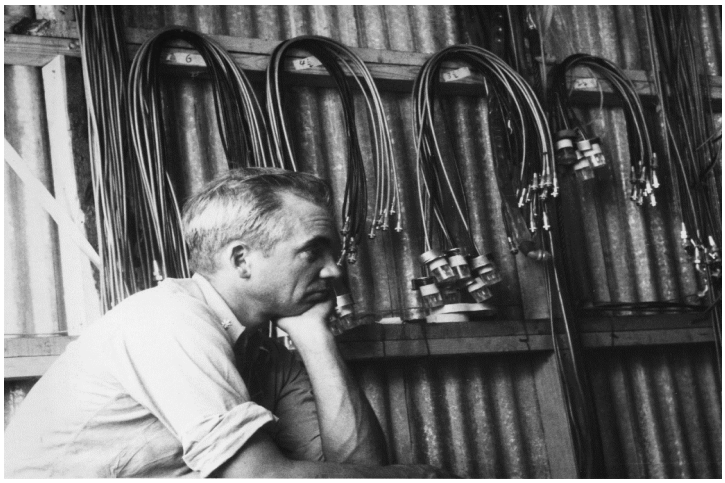

Figure 13. Norris Bradbury sitting in Trinity Shot Cab, July 1945. LANL Archives.

The Bikinians

On February 10, 1946, just one month after Truman authorized Crossroads, Navy Commander Ben Wyatt, the Military Governor of the Marshall Islands, told the Bikinians, after

[70]Since the Navy controlled Crossroads, the tests became known colloquially as the Navy tests.

[71] N. E. Bradbury to L. R. Groves, LANL Archives, April 12, 1946.

[72] R. Larkin to L. R. Groves, LANL Archives, August 30, 1945; *Bradbury's Philosophy*, LANL Archives, October 1, 1945.; and John Manley, *Function and Organization*, LANL Archives, n.d.

their Sunday church service, that they had to leave their homeland as did the biblical Abraham, who obeyed God without question. The imagery was not lost on the Bikinians, who, as noted by anthropologist Robert Kiste, believed in *"a literal interpretation of the Bible from the account of creation in Genesis to the last book in the New Testament."*[73] Although the Bikinians had been living on their atoll for 2,000 years, their unique culture tied directly and intimately to their atoll, the Navy didn't care. Bikini Atoll met the technical and logistical requirements of Crossroads, making its people an impediment to be removed. Moving quickly, the Navy flew Juda, the Bikini Iroij, to inspect nearby Rongerik Atoll. Rongerik was uninhabited and, from the Navy's perspective, indistinguishable from Bikini. Juda, and nine of the eleven Bikini alaps (family heads) agreed to make the pilgrimage to Rongerik. Once the paramount Iroij of the Ralik Chain, Lajrwe, gave his approval, the Navy constructed twenty-six homes, canvas water tanks, screened toilets, and nine concrete cisterns on Rongerik for the Bikinians. Despite misgivings and some misunderstandings, especially among the women, and with some dissatisfaction and nostalgia, the Bikinians were relocated on March 7th creating a Diaspora that continues today.

Table 1
Operation Crossroads

Test Codename	Date	Device Nick Name	Yield (kt)
Able	06/30/1946	Gilda	21
Baker	04/24/1946	Helen of Bikini	21
Charlie	~1947	None	Est. 21

Operation Crossroads had seven military goals:

- *To determine the effects of atomic bombing on naval vessels, naval material, and ships' crews.*

[73] Robert C. Kiste, *Kili Island: A Study of the Relocation of the Ex-Bikini Marshallese* (Eugene Oregon, 1967), 315.

- *To provide the Army Air Forces with expertise in precision (atomic) bombing.*
- *To ascertain the effects of atomic bombing on a variety of army material.*
- *To show the kinds and extents of biological and chemical effects produced by radiations of all kinds.*
- *To discover successful means of diagnosing and treating persons exposed to radiation.*
- *To help answer a variety of hitherto-unanswered scientific questions in the fields of blast, meteorology, radioactivity, oceanography, seismography, radio propagation, and ionization.*
- *To determine the remote detectability of atomic bomb explosions.*[74]

To accomplish these goals, the Navy assembled 342 ships, 242 aircraft, and 42,000 personnel at Bikini and Kwajalein Atolls.[75] Ninety-three ships, including the Japanese battleship Nagato, the German cruiser Prinz Eugen, and the United States aircraft carrier Independence, were specifically chosen as targets.[76] These vessels, carrying varying amounts of munitions, fuel, and animals, were anchored in a precise pattern around the projected point of detonation so that the destruction phenomenology of each bomb could be accurately measured.

Although Los Alamos participation in Crossroads was limited to bomb production, Bradbury told Groves that *"It is anticipated that a decision will shortly be required concerning the character of the second Naval test at Bikini Atoll. It is, therefore, desired to record the thinking of Los Alamos in this matter in case our conclusions may be of use to those charged with making the final decision."* Bradbury recommended the underwater test be *"carried out at a depth of about 75 ft. plus or minus 15 ft.,"* since this would better answer *"the fundamental question of how an atomic bomb reacts with a water surround."* Bradbury also told Groves that

[74] W. A. Shurcliff, *Technical Report of Operation Crossroads* (Washington, D. C.: Joint Task Force-1, 1946), 1-10.

[75] All command and support activities took place on Kwajalein.

[76] Many obsolete United States naval vessels were included as target ships.

"placing the bomb in too deep under water brings it too close to the very rough bottom of the atoll, thereby increasing the difficulty of interpretation of the results."[77] Although Bradbury did not receive a reply, the second test, codenamed Baker, was conducted as he suggested.

The Plutonium parts for Gilda and Helen of Bikini were carried to the Marshall Islands in the backpacks of two Los Alamos physicists, who flew from New Mexico to California and then sailed to Kwajalein Atoll aboard the USS Mount McKinley. One of the couriers, Raemer Schreiber, described the security system used to protect the Plutonium parts during the sea voyage to Kwajalein. The parts, said Schreiber, were supposedly in a strongbox bolted to the ship's main deck guarded by a couple of lieutenant-grade MPs with a squad of men. However, Schreiber and his fellow Los Alamos courier kept track of the real components, still in their backpacks, stored far below the main deck in the lieutenants' cabin.[78] At Kwajalein, ropes were tied to the ship and each backpack. Should a courier slip and fall walking down the gangplank, the ropes would prevent the Plutonium parts from falling into the waters. As Schreiber wryly noted, the couriers were expendable.[79]

A wide variety of people were invited to witness Gilda including twenty members of Congress; 189 reporters, including an editor of *Canning Age* and *Food Freezing* magazines;[80] eighteen foreign reporters; and twenty-one representatives from the United Nations Atomic Energy Commission, including two Soviets. Los Alamos sent 149 scientists and engineers to assemble and arm the two atomic bombs. Only one Bikinian, Juda, witnessed test Able, and that by accident. Juda had been brought back from Rongerik to see the vast armada prior to the first

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[77] N. E. Bradbury to L. R. Groves, LANL Archives, April 12, 1946.

[78] Raemer E. Schreiber*, LA-11929-H: An Eyewitness Account*, LANL Archives, 205.

[79] Ibid.

[80] Author Unknown, *Bomb at Bikini: The Diary of a Crossroads Correspondent* (Author's Collection, n.d.).

test. During the frenzied activities leading up to test Able, he was forgotten. When he saw that Bikini was untouched by Gilda, Juda was not impressed.

Twenty-four days after Gilda, Helen of Bikini, encased in a bathysphere fashioned from a submarine conning tower, was detonated ninety feet below the surface of Bikini's lagoon.[81] The depth of the detonation matched, approximately, that recommended by Bradbury. In contrast to Gilda, Helen of Bikini was spectacular, her energy burst through the lagoon surface at 11,000 ft./sec pushing over two million cubic feet of radioactive seawater and sediment to a height of 4,300 feet within the first minute after detonation. Nine vessels, including the Nevada, were sunk and an additional five ships were essentially destroyed, although still afloat.[82] The damage caused by Helen of Bikini was far more serious than it appeared because the column of radioactive sediment and seawater spread over the remaining ships in the lagoon, thoroughly contaminating them. It quickly became clear that these ships could not be decontaminated because radioactivity bonded to exterior surfaces and permanently embedded itself in the ventilation systems. One of those contaminated ships, the Prinz Eugen, was towed to Kwajalein Atoll in hopes that it could be salvaged, but the ship sank because radioactivity prevented salvage crews from entering the ship's interior to stop the leaks caused by the blast wave. Today, at low tide, the Prinz Eugen is visible from Kwajalein Island's shore. Most of the remaining fleet was sunk in deep water. A few vessels were used for decontamination training before they, too, were scuttled.

[81] United States Department of Energy, *United States Nuclear Tests: July 1945 through September 1992* (U. S. Department of Energy Nevada Operations Office, 2015).

[82] W. A. Shurcliff, *Technical Report of Operation Crossroads,* 1-10.

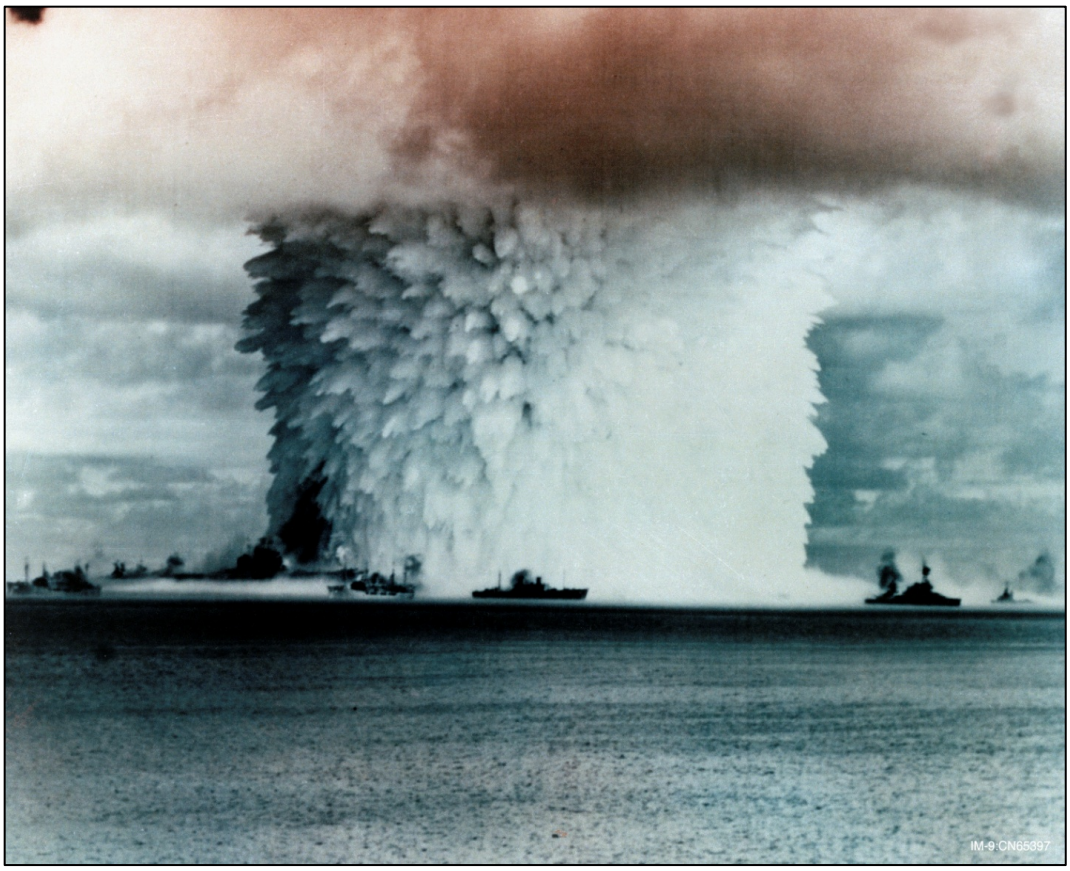

Figure 14. Helen of Bikini, LANL Archives.

The Technical Assessment

Parsons, now a Rear Admiral, wrote a very sanguine assessment of Crossroads, saying,

> *Both tests came off on schedule. A vast amount of information valuable to scientists, engineers, and strategists was amassed. The Army Air Forces, in the course of its extensive program of training and practicing for the A-Day drop, gained knowledge of new techniques and achieved reliability and precision never before attained. The Navy's major postwar problem, previously only vaguely defined, is now more clearly posed. A sound basis has been created for designing ships offering considerably increased resistance to the fury of the world's most powerful weapon, the atomic bomb.*[83]

[83] W. A. Shurcliff, *Technical Report of Operation Crossroads*, 3.73.

Parsons' assessment, however, made little sense. Neither Gilda nor Helen of Bikini generated any new scientific data. As the third and fourth Fat Man bombs to be detonated, they only confirmed what was already known, that the Fat Man design could be reproduced at will. As historian Barton Hacker noted, *"science took a back seat"* at Crossroads.[84] Gilda, like Fat Man at Nagasaki, missed its aiming point by a significant margin, negating any claims about precision bombing. However, like the experience at Nagasaki, Gilda showed that a miss by an atomic bomb didn't really matter much. The damage was considerable, even for ruggedly built naval vessels. Helen of Bikini demonstrated that radioactivity rendered ships unusable just as effectively as if they were sunk. Building more rugged ships would not change this condition. Not widely known today, and certainly not spoken of at the time, the detonations of Gilda and Helen of Bikini depleted the nation's stockpile of nuclear weapons. This was of considerable importance because the tests, which both the military and politicians opened up to the world to witness, were not, as William Lawrence reported, overly convincing.

When the Navy sailed from Bikini after completing Operation Crossroads, it left behind an atoll littered with abandoned structures and vehicles and a lagoon contaminated with sunken ships leaking oil and the organic waste of 42,000 people. Radioactivity from Helen of Bikini eventually concentrated in the biota of the lagoon, particularly in the algae and shellfish. Five years after Crossroads, in 1951, Neil Hines, working for the University of Washington's Applied Fisheries Laboratory, travelled to Bikini on one of the expeditions that periodically checked for radioactive contamination in and around Bikini. With the exception of the continuing oil leaks from sunken ships, the lagoon showed no other signs of contamination.[85]

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[84] Barton C. Hacker, *Dragon's Tail Radiation Safety in the Manhattan Project, 1942-1946* (Berkeley: University of California Press, 1987), 116.

[85] Ibid.

Los Alamos and the Bikinians

Despite the lack of new technical information, Crossroads reconfirmed the central importance of Los Alamos to the nation. *"The plain fact is,"* as Parsons told Bradbury, *"the 1945 Atomic bomb is a one-laboratory instrument and that Laboratory is Los Alamos."*[86] Crossroads also improved the personnel situation at Los Alamos particularly by providing well-paying jobs for the Laboratory's graduate students, such as radiochemist George Cowan. For Cowan and others, the money they earned participating in Crossroads allowed them to finish graduate school and, in many cases, get married. Using his Crossroads money, Cowan completed his graduate education, returned to Los Alamos, and became one of the most accomplished radiochemists in the country.[87]

The most significant consequence of Crossroads, however, was its impact on the Bikinians and their atoll. Although the two bombs of Operation Crossroads did surprisingly little physical damage to the atoll, a fact Juda had ruefully noted, the Navy had no plans to return the Bikinians to their homeland and did not even bother to monitor their wellbeing. As a result, the Bikinians nearly starved because they believed an evil spirit had poisoned the fish in the atoll's lagoon and because a fire destroyed many of the atoll's coconut trees. Not until anthropologists reported the plight of the Bikinians to the world press, did the Navy take any action. In response to international criticism, the Navy planned to move the Bikinians to yet another uninhabited atoll, Ujelang, even though periodic surveys of Bikini Atoll did not find any radioactivity sufficient to keep the islanders from returning.[88] Before the Bikinians could be moved, however,

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[86] W. S. Parson to N. E. Bradbury, *Possible Tests of Atomic Bombs Against Naval Vessels*, LANL Archives, 10/26/1945.

[87] George Cowan, personal communication, 2002.

[88] Neil O. Hines, *Proving Ground: An Account of the Radiobiological Studies in the Pacific, 1946-1961* (Seattle: University of Washington Press, 1962).

the Atomic Energy Commission selected Ujelang for the natives of Enewetak Atoll, who, themselves, were about to be evicted for the 1948 Operation Sandstone tests. The Bikinians were moved, instead, to Kwajalein, where they lived in tents while waiting for their future to be decided. Evicted from their homeland without compensation and sent to what amounted to a foreign land, the Bikinians were forced into a modern-day Diaspora. Whether intended or not, the relocation of the Bikinians may be permanent.

Chapter 4: The Atomic Energy Act and Operation Sandstone

On April 3, 1947, three months after the Atomic Energy Commission replaced the Manhattan Engineer District, AEC Chairman David Lilienthal handed President Truman a written assessment of the nation's nuclear weapon stockpile. *"When he came to a space I had left blank [for the number of weapons in the stockpile],"* Lilienthal recorded in his diary, *"I gave him the number; it was quite a shock. He turned to me, a grim, gray look on his face, the lines from his nose to his mouth visibly deepened. What do you propose to do about it?"*[89] Truman learned for the first time that the nuclear arsenal of the United States was a collection of parts for a very small number of bombs.[90] As Truman noted, *"Our atomic armament was inadequate, both qualitatively and quantitatively, and the tempo of progress throughout dangerously slow."*[91] Oppenheimer, now chairman of the AEC's General Advisory Committee, said the job of the Atomic Energy Commission, *"was to provide atomic weapons and good atomic weapons and many atomic weapons."* Writing years later, McGeorge Bundy said, *"any revelation of American impotence would be profoundly shocking, most of all to the American people."*[92]

The Atomic Energy Act of 1946

In May 1945, two members of the War Department's secret Interim Committee; Vannevar Bush, Director of the Office of Scientific Research and Development (OSRD); and James Conant, Chair of the National Defense Research Committee (NDRC); proposed that the

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[89] David E. Lilienthal, *The Journals of David E. Lilienthal, Vol. 2: The Atomic Energy Years, 1945-1950* (New York: Harper and Row, 1964), 165 and *Report [redacted and abridged] to the President of the United States from the Atomic Energy Commission: January 1, - April 1, 1947*. Author's copy.

[90] N. E. Bradbury, *Road Status Report, 1946*, LANL Archives. "Road" was the code name for the stockpile.

[91] Harry S. Truman, *Memoirs, Vol.2: Years of Trial and Hope* (New York: Doubleday & Company, 1956), 299.

[92] McGeorge Bundy, *Danger and Survival: Choices about the Bomb in the First Fifty Years* (New York: Random House, 1988), 202-203; Clark Clifford and Richard Holbrooke, *Counsel to the President*: *A Memoir* (New York: Random House, 1991), 4 and 36; PL 235-61; U.S.C. 402.

MED be replaced by a civilian agency.[93] Shortly after the war, their proposal was crafted into draft legislation and submitted to Congress as the May-Johnson Bill. The bill proposed the creation of an atomic energy commission consisting of five civilian and four military members who would have *"broad powers to acquire property, to operate facilities, to conduct research, and to regulate all forms of nuclear energy."* May-Johnson[94] met with instant opposition because a commission composed of nearly equal civilian and military members smacked of continued military control. Senator McMahon introduced alternative legislation, the Atomic Energy Act, which would create a civilian executive agency, the Atomic Energy Commission. McMahon's bill passed both houses of Congress and was signed into law by President Truman August 1, 1946, after being amended to give the national military establishment a statutory role in the development of nuclear weapons through the creation of the Military Liaison Committee (MLC). The Act became effective on January 1, 1947.

The Atomic Energy Act created, in Congress, the Joint Committee on Atomic Energy (JCAE) consisting of nine members from the Senate and nine from the House having responsibility for *"continuing studies of the Atomic Energy Commission and of problems relating to the development, use, and control of atomic energy."* Within the Executive Branch, the Act created, the Atomic Energy Commission (AEC) consisting of five presidentially appointed civilian commissioners having the responsibility for meeting the overall requirements of the Act. Within the AEC, the new law created the Division of Military Application (DMA) headed by a military officer. The DMA was the Commission's executive agent for coordinating the design, development, and testing of atomic bombs. The DMA, to which Los Alamos formally reported, also coordinated the interests of the Commission and the MLC. Within the AEC as

[93] http://en.wikipedia.org/wiki/Interim_Committee.

[94] Congressman Andrew May (D-KY.) and Senator Edwin Johnson (D-CO.)

well, the Act created a General Advisory Committee (GAC) to advise the Commission on scientific and technical matters. As a panel of experts with international reputations, including Oppenheimer, the GAC's opinion was highly regarded. Within the national military establishment, the Act created The Military Liaison Committee composed of members from the Departments of War and Navy (and later Air Force). The MLC codified the military requirements for nuclear weapons as well as providing the resources for conducting nuclear tests.[95] The creation of the MLC inaugurated a demand economy in which all new weapons were developed to meet specific military needs.

Operation Sandstone

In mid-January 1947, Norris Bradbury sent a long letter to the AEC outlining his vision and mission for Los Alamos, beginning with the understated caution that *"of the many problems facing your Commission, that presented by the Los Alamos Laboratory may well not be the least."* In his letter, Bradbury described in detail the Lab's wartime mission, the postwar situation in which the MED maintained the *"status quo,"* and his belief that the Los Alamos mission ought to be *"directed not only at maintaining an immediate superiority, but also toward maintaining general scientific progress … which will make for strength in the future."* Such progress required new and better weapons which, in turn, required proof of principle tests. *"It is far from clear,"* said Bradbury, *"how the laboratory may function energetically on weapon development problems without the possibility of periodic tests of its accomplishments."* Bradbury ended his letter by saying that he and his staff were very much *"concerned with the Commission's reaction to his proposals."*[96] Despite the importance of the issues, Bradbury

[95] *Atomic Energy Act of 1946*, Public Law 585, 79th Congress. The MLC was abolished in 1987 and replaced by the Nuclear Weapons Council (P.L/ 99-661).

[96] N. E. Bradbury to Carroll Wilson, LANL Archives, January 13, 1947.

received no response. The AEC existed only on paper, its commissioners waiting on Senate confirmation. Bradbury's letter arrived, but *"there was in fact no one to receive it."*[97]

However, matters quickly improved allowing Bradbury to secure both GAC and AEC approval for a three-shot test series. If successful, these tests would be significant improvements over the crude wartime weapons. President Truman authorized the test series, now codenamed Sandstone, during a June 27, 1947, meeting with Lilienthal, Secretary of State George Marshall and Secretary of Defense, Robert Patterson. Despite objections from the secretaries, Truman ordered Sandstone to be conducted somewhere in the Pacific. Both Marshall and Patterson questioned the need to send nuclear devices outside the continental United States during a time of increasing tensions with the Soviet Union. Although the President did not specify where in the Pacific the tests should be conducted, it was tacitly acknowledged that once again, one or more atolls in the Marshall Islands would serve as ground zero.[98]

By an informal agreement that rotated responsibility for weapon test operations among the service branches, the JCS appointed Army Chief of Staff Dwight Eisenhower executive agent for Sandstone. Eisenhower, in turn, created Joint Task Force 7 (JTF-7) under the command of Army Lieutenant General John S. Hull. The AEC appointed Navy Captain James Russell, head of its DMA, to the position of Test Director. Bradbury appointed Darol Froman to the position of Scientific Director. Hull, Russell, and Froman travelled to the Marshall Islands in October 1947 to select a test site. Even before they left, Bikini had been ruled out. The atoll did not have enough land area to accommodate three tests along with the requisite command and support

[97] Richard G. Hewlett and Francis Duncan, *Atomic Shield. A History of the United States Atomic Energy Commission, Volume II, 1947-1952* (Berkeley: University of California Press, 1990), 32.

[98] *Operational History of Atomic Energy Proving Ground Group*, LANL Archives, 1948; Richard Hewlett, *Atomic Shield,* 48 and 84-85; and James Russell, *Report to the US Atomic Energy Commission on Operation Sandstone Atomic Weapons Proof Tests* (Washington, D.C.: Joint Task Force 7, 1948), 1-4 through 1-6.

facilities. Another Marshallese atoll, Kwajalein, specifically the Roi-Namur islands located at the northern apex of the atoll's lagoon, appeared suitable. A military base, including docking facilities located at the southern apex of the atoll on Kwajalein island, promised to keep shipping and other costs to a minimum. However, Roi and Namur were too close together to permit the simultaneous construction of three shot towers. The second and third towers could only be built after each preceding detonation.[99] All of the nearby islands, actually islets, were far too small to be of any use. A second drawback was the relatively large average amount of rainfall in the area. Frequent rains could delay test operations, and, if they occurred immediately after a shot, prevent the dispersal of the radioactive clouds over the open ocean.

Ruling out Kwajalein Atoll, Hull, Russell, and Froman flew to Enewetak, which, after a quick inspection, appeared ideal, particularly because of the relatively large size of individual islands and their orientation with respect to the prevailing wind pattern. The three shot towers could be built simultaneously on the northern islands of Engebi, Aoman-Bijiri, and Runit. The southern islands, including Enewetak, were large enough to support the JTF facilities. Most importantly, none of the shots would interfere with each other radiologically. The tests would be fired from north to south beginning with Engebi, followed by the twin islands of Aoman-Bijiri, and finally the island of Runit.[100] The prevailing winds would push the radioactive clouds over the previously used (and abandoned) ground zero islands and then out to sea. As a bonus, Enewetak was well off the normal shipping and air transportation lanes. The absence of commercial ship traffic would make security, such as locating any Soviet ships and submarines, much easier. And, finally, a quick study showed that logistical costs were no more prohibitive

[99] Ground zero sites were key since shot towers for all three tests had to be constructed simultaneously both to minimize construction time and to minimize the overall time required to carry out tests. Hence each site had to be far enough away from each other so that any one test did not damage or destroy other shot towers.

[100] Since Aoman and Bijiri were separated only by a narrow gap, a causeway was built connecting the islands, allowing them to be used as one entity.

than those that would have been incurred at Kwajalein. Hull, Russell, and Froman quickly settled on Enewetak and work crews soon began clearing the shot islands of vegetation for the construction of the towers and instrumentation bunkers. The major islands on the southeast perimeter of the atoll - Parry and Enewetak – became the administrative and logistical home of Sandstone (as well as later test operations). Major docks were built on both islands to accommodate heavy ships, along with a major airstrip on Enewetak for large transport planes. Smaller docks and airstrips on other islands were built to accommodate a fleet of water and air taxies and the drone aircraft that would collect radioactive samples.

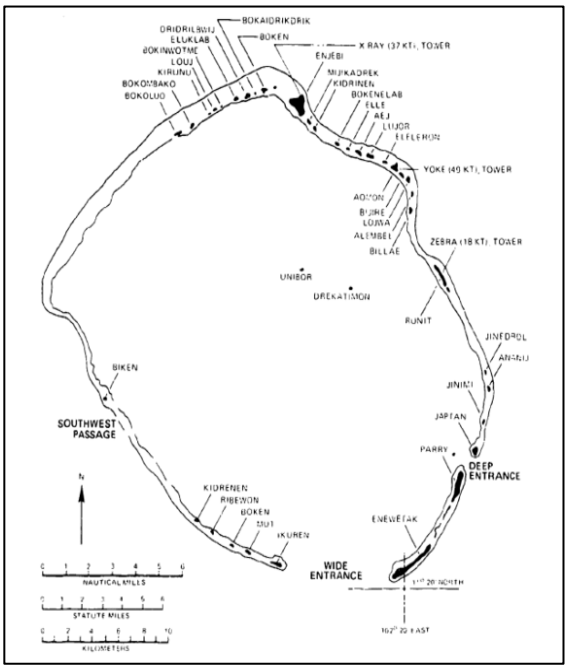

Figure 15. Enewetak Atoll. LANL Archives

The Enewetak People

In the middle of this construction activity sat the two Enewetak tribes living, as they had been since 1944, on Aoman and Bijiri. The wartime devastation of their home islands, Engebi and Enewetak, as well as their later use by the U.S. military, kept the two native tribes on Aoman and Bijiri long after hostilities had ended. Unlike the removal of the Bikinians in 1946, the

Enewetak people could not be arbitrarily relocated because they were now the legal responsibility of the United Nations. The Marshallese Trusteeship stipulated that the United States had to provide sufficient evidence that relocating the Enewetakians would not subject *"the local inhabitants of the Trust Territory of the Pacific to perceptibly greater danger than say, the people of the United States."* Relocating both tribes to another atoll, Ujelang, seemingly met this condition. Undersecretary of State Robert Lovett, in a disingenuous manner, suggested telling the UN Security Council that relocating the Enewetakians was not significant since they were not even living on their home islands. This was a curious statement given that the Enewetakians had been removed from their home islands by the U.S. Navy and prevented, as well, from returning to their homes after the war. Despite the obvious contradiction that the risk of exposure to radioactive fallout fell squarely on the Marshallese and their islands., the UN approved the relocation of the Enewetak people. On December 3, 1947, the two Enewetak Iroij, Johannes and Abraham, were flown to the Ujelang Atoll to judge its suitability for relocation. Both Iroij approved and on December 20, 1947, the people of Enewetak were moved by a Navy ship to their new home, although not before Los Alamos complained that the relocation was taking too long, putting construction behind schedule.[101]

Table 2
Operation Sandstone

Test Codename	Date	Island	Yield (kt)
X-Ray	04/14/1948	Engebi	37
Yoke	04/30/1948	Aoman-Bijiri	49
Zebra	05/14/1948	Runit	18

[101] J. Clark to D. Froman, LANL Archives, December 7, 1947.

Just before dawn local time (18:17 GMT) on March 14, 1948, an implosion device codenamed X-Ray was detonated on the northwest end of Engebi Island giving a yield of 37 kilotons, a considerable increase over the yield of Fat Man. X-Ray, designed during the war to make better use of the available fissionable material, came too late for use in combat. After the war, X-Ray entered the stockpile in limited numbers, despite the lack of a proof test. Operation Sandstone was the first opportunity to obtain *"certain knowledge on this point."*[102] The second test, Yoke, was fired on April 30th over the sands of Aoman-Bijiri, giving a yield of 49 kilotons. Yoke was never stockpiled because it was cumbersome and difficult to build. The third and final test of Sandstone, Zebra, a design developed to test an all uranium implosion assembly, was detonated on May 14th over Runit Island giving a yield of 18 kilotons.[103]

Darol Froman reported to Congress that the most significant outcome of Sandstone was an immediate improvement of the nation's nuclear stockpile. Test X-Ray allowed this type of weapon to be added to the stockpile with confidence. The successful Zebra test meant that the stockpile also could be dramatically increased with the inclusion of this type of weapon. In short, as Froman told Congress, not only would new weapons *"of improved efficiency and performance"* enter the stockpile, Sandstone also insured that *"Los Alamos will undoubtedly be able to further improve the design of atomic weapons."* [104] The New World, more myth than reality since the end of the war, now had substance.

Radiation Injuries

[102] Joint Task Force 7, *Operation Sandstone Vol. 7* (Washington, D.C.: Joint Task Force 7).

[103] United States Department of Energy, *United States Nuclear Tests: July 1945 through September 1992, DOE/NV-209-Rev. 15, December 2000.*

[104] D. Froman, *Congressional Testimony*, LANL Archives, 1948; William Ogle, *An Account of the Return to Nuclear Weapons Testing by the United States After the Test Moratorium, 1958-1964*, 31.

The technical success of Sandstone, however, was marred by beta radiation burns to four Los Alamos scientists. These scientists, radiochemists responsible for collecting, packaging, and shipping radioactive debris to Los Alamos for analysis, were injured when they used their bare hands to accelerate the recovery and shipping of collection filters to Los Alamos.[105] Such burns resemble those caused by the sun, but do not manifest themselves immediately. Although Darol Froman took responsibility for the situation, saying that he, as the Scientific Director, failed to provide *"a flawless practical means for ensuring that no individual could expose himself to injurious amounts of radiation,"* no real investigation was done to determine just why radiochemists, of all people, would deliberately expose themselves to ionizing radiation.[106] Although the damage to each individual was permanent, all eventually returned to work.

[105] At Sandstone, radioactive debris was collected by filter units mounted on drone aircraft flown through the radioactive clouds of each test. Recovery and handling of the filter units was normally done with remote handling tools. A beta particle, also called beta ray or beta radiation, is a high-energy, high-speed electron or positron emitted by the radioactive decay of an atomic nucleus during the process of beta decay. Beta particles are especially dangerous to skin and eyes. Definition from Wikipedia.

[106] D. Froman*, Status of Men Damaged by Radiation on Operation Sandstone*, LANL Archives, May 8, 1949. There were safety measures in place at Sandstone, including the accepted practice, dating from the war, to trust each person's judgment to stay out of harm's way. This reliance on people's technical knowledge did have some merit. No one was seriously injured by radiation during the war. However, lethal criticality accidents at Los Alamos in November 1945 and May 1946, brought this practice into question and led to the creation of remote handling tools. Unfortunately, this practice was not followed at Sandstone. All four men returned to work with varying amounts of permanent scarring and damage.

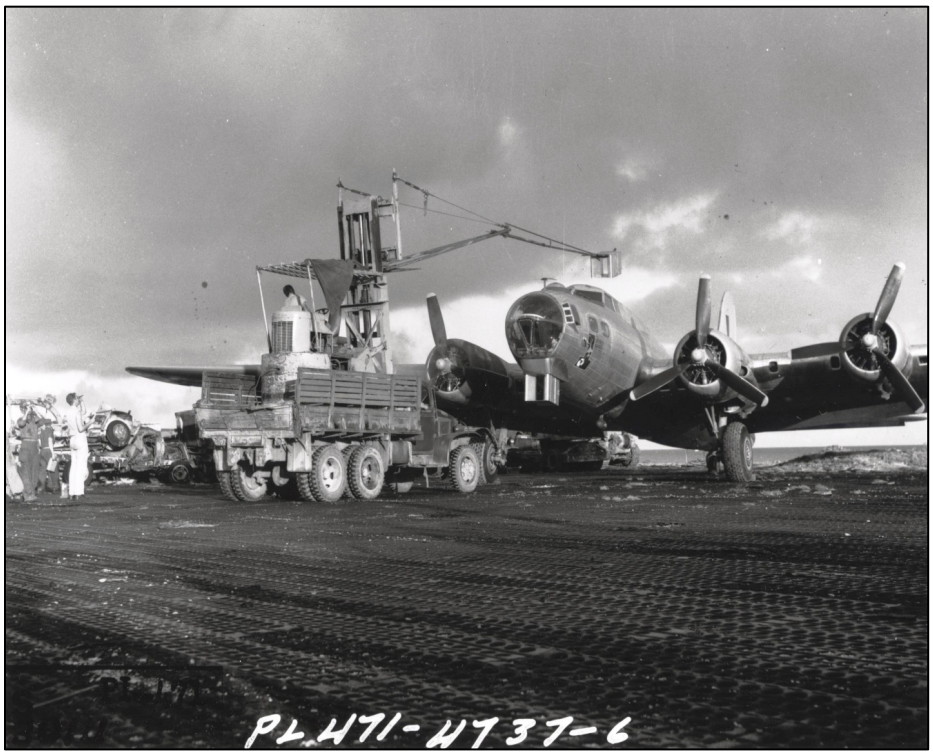

Figure 16. Recovery of radioactive debris samples from a B-17 drone aircraft. LANL Archives.

Cultural Insensitivity

What was the impact of Sandstone on the people of Bikini and Enewetak? First, the Bikinians remained on Kwajalein living in tents. Second, on Ujelang, the Enewetak people had their tribal identities nearly erased. The American built facilities did not take reflect the tribal compositing of the Enewetak people. The custom of dividing land by family from lagoon to ocean was ignored. The result was a permanent dissolution of tribal identity through mixed marriages and crossed land rights.[107] Sandstone, in short, created a second Marshallese diaspora, one that partially remains today.[108]

[107] Defense Nuclear Agency, *The Radiological Clean-up of Enewetak Atoll* (Washington, D.C.: The Defense Nuclear Agency, 1985), 21-22.

[108] Some of the Enewetak people have returned to the southern islands of their atoll, but the northern islands remain uninhabitable.

Chapter 5: Fission to Fusion: An Island Goes Missing

Hollywood actor Reed Hadley walked the decks of the USS Estes with the practiced ease characteristic of his profession. Stopping periodically, relighting his pipe to provide dramatic pauses, he narrated an AEC film depicting the final hours leading up to the detonation of Mike, the world's first thermonuclear bomb. Hadley's smooth camera presence contrasted sharply with those of the scientists and technicians he interviewed. Alvin Graves, the Scientific Director, came across particularly wooden and condescending in his answers to Hadley's questions. [109] Just after Hadley put on his dark goggles to prevent flash blindness, Mike exploded at 2:30 pm Eastern Standard Time on November 1, 1952, with a force of 10.4 megatons, completely vaporizing the ground zero island of Elugelab along with portions of two nearby islands.[110] The film made one thing clear – Los Alamos scientists could build a thermonuclear bomb, but they could not act.[111]

Edward Teller, the putative father of the hydrogen bomb, knew within minutes that the test was successful. Watching a seismograph in the basement of the geology building at the Berkeley campus of the University of California, Teller waited to see evidence of Mike's shock wave. *"At exactly the scheduled time,"* said Teller*, "I saw the light point move. The sound waves took twenty minutes to carry the message under the Pacific and arrive at Berkeley."*[112]

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[109] Alvin Graves and his wife, Elizabeth, also a physicist, came to Los Alamos from the University of Chicago in 1944 and elected to stay at Los Alamos after the war. In May 1946, Graves was seriously injured in the Slotin criticality accident. He lived primarily because Slotin's body protected him from receiving a lethal dose of ionizing radiation. After his recovery, Graves became the Deputy Scientific Director for Operation Sandstone in1948. In 1951, he became the scientific director for the 1951 Greenhouse Operation and continued in that role for Operations Ivy and Castle.

[110] *DOE/NV-209*.

[111] *Operation Ivy Motion Picture*, LANL Archives.

[112] Edward Teller and Judith Schoolery. *Edward Teller: Memoirs – A Twentieth Century Journey in Science and Politics* (Cambridge, Massachusetts: Perseus Publishing, 2001), 352; Edward Teller, *The Legacy of Hiroshima* (Garden City, NY.: Doubleday, 1962), 55; and Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Simon & Schuster, 1995), 511.

Confirmation of the detonation reached Gordon Dean, Chairman of the Atomic Energy Commission, in Washington, D.C., by way of the Pentagon's communications system. Dean waited until evening to inform President Truman, who was campaigning in the Midwest for presidential candidate Adlai Stevenson. In a very guarded conversation required by secrecy rules, Dean told the President *"On the matter which I discussed with you the other evening this is simply to report that the mission was carried out with highly successful results. I'm doing everything possible to keep this info from becoming public until after Tuesday [Election Day]."* Truman was pleased to hear the news. As Dean recorded in his office diary, the president said *"he appreciated the situation and thanks a lot."*[113]

Figure 17. Mike. Photo taken from a distance of fifty miles. LANL Archives.

[113] Gordon E. Dean and Roger Anders, *Forging the Atomic Shield: Excerpts from the Office Diary of Gordon E. Dean* (Chapel Hill: University of North Carolina Press, 1987), 229-230; and Richard Hewlett, *Atomic Shield*, 592-593.

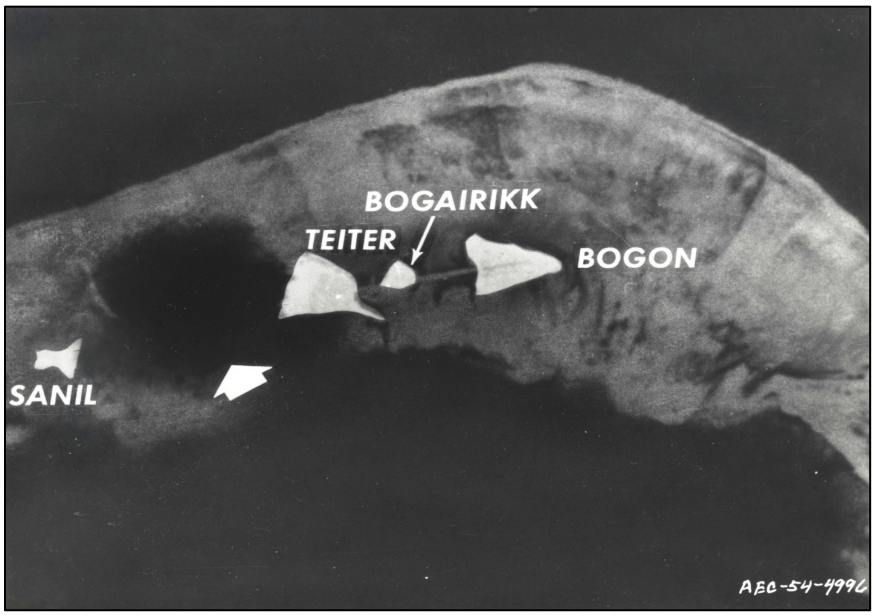

Figure 18. Mike Crater - shown by the large arrow on the left - created when Mike vaporized the island of Elugelab. LANL Archives.

Origins

In the summer of 1942, at the request of the National Bureau of Standards, J. Robert Oppenheimer convened a small summer conference of his colleagues, including Edward Teller, at the University of California to analyze existing research on fission. During one session, Teller, out of the blue, "*brought up the super, a detonation wave in liquid deuterium heated by an atomic bomb.*[114] *Everybody turned eagerly to discuss the super forgetting all about the atomic bomb as if that was an accomplished fact already!"*[115] The eagerness quickly faded because even if an atomic bomb could ignite Deuterium, radiation cooling, known as the Inverse Compton Effect, would stop the thermonuclear process before an explosion took place.[116]

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[114] Deuterium and Tritium are isotopes of hydrogen that have lower ignition temperatures then the base element hydrogen. Deuterium is relatively easy to produce, tritium is not.

[115] Robert Serber, *Oral Interview*, LANL Archives, 1986; and Lillian Hoddeson, et al., *Critical Assembly: A Technical History of Los Alamos during the Oppenheimer Years, 1943-1945* (New York: Cambridge University Press, 1993), 44-47. The hydrogen bomb went by several names: "hydrogen bomb," "thermonuclear bomb," and "super" bomb. Hydrogen bombs became theoretically possible in 1938 when Hans Bethe solved the mystery of solar luminosity - that the very high temperatures found in stars compress and combine atoms of hydrogen into helium and, in the process, liberate *"some of the binding energy that holds the nucleus of an atom together."*

[116] *Serber Oral Interview*, LANL Archives, 1988.

Although technical complexities made the development of the hydrogen bomb for use in World War II unlikely, it could not be completely ignored. And so, when Oppenheimer organized the Los Alamos Laboratory a year later, he recruited Teller to lead the "Hydrodynamics of Implosion and Super Group."[117] Oppenheimer knew, if nothing else, that *"the technical challenges provided a sense of excitement."*[118] When Teller became restive at working on implosion, Oppenheimer created a new group, "The Super and General Theory" under Teller's leadership to explore and quantify possible detonation systems. Although Teller and the new group did not accomplish a great deal, they did make enough progress to keep hydrogen bomb work alive. Norris Bradbury kept this work going after the war, organizing a conference in the summer of 1946 to assess both the wartime work as well as the overall feasibility of a hydrogen bomb. Although major technical hurdles had yet to be overcome, the conference concluded *"the super bomb can be constructed and will work."* Recognizing that the explosive potential of a hydrogen bomb made such a weapon even more destructive than an atomic bomb, the conference also concluded that the decision to pursue this weapon needed *"to be raised to the highest national power."* [119] That would not happen for another three years.[120]

In July 1949, at the instigation of the Joint Chiefs of Staff, President Truman created a special subcommittee of the National Security Council (NSC) to review the nuclear posture of the United States including a complete analysis of the nation's nuclear assets. Although the Chairman of the AEC was not normally part of the NSC structure, Lilienthal was asked to join

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[117] Hawkins, *Project Y: The Los Alamos Story,* p. 76.

[118] Carson Mark*, LA-5467-MS: A Short Account of the Los Alamos Theoretical Work on Thermonuclear Weapon,* LANL Archives, 1971, 3.

[*119*] *LA-575: The History of the Super* (Deleted Version), LANL Archives.

[120] *Sidney Souers Oral History*, Truman Library; and N.E. Bradbury to the AEC, LANL Archives, 1947.

Secretary of State Dean Acheson and Secretary of Defense Louis Johnson as one of only three subcommittee members. Truman instructed them *"to assess the rate of progress being made in our atomic program."* They subcommittee quickly found that the nation's infrastructure was inadequate with respect to fissionable materials production and recommended to the president that the nation's atomic program be accelerated.[121]

While the subcommittee's findings detailed shortcomings and the need for improvement, there was no sense of extreme urgency or panic. The United States had, after all, a monopoly on nuclear weapons. Although it was assumed that the Soviet Union would likely develop an atomic bomb at some stage, most authorities believed the effort would take years. General Leslie Groves predicted twenty, while most scientists thought it would take only about five. No one, however, had a clear idea of Soviet capabilities and were surprised when a B-29 snooper aircraft flying over Alaska picked up radioactive debris from a Soviet nuclear detonation. Soon after, contaminated rainwater samples collected on the roof of the National Bureau of Standards building in Washington confirmed the B-29 data.[122] The Soviet Union had detonated its first atomic bomb, which the U.S. quickly nicknamed Joe 1, on August 28, 1949.[123] President Truman announced the Soviet detonation on September 23rd, saying:

> *I believe the American people, to the fullest extent consistent with national security, are entitled to be informed of all developments in the field of atomic energy. That is my reason for making public the following information. We have evidence that within recent weeks an atomic explosion occurred in the U.S.S.R. Ever since atomic energy was first released by man, the eventual development of this new force by other nations was to be expected.*[124]

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[121] Harry S. Truman, *Years of Trial and Hope*, 302; McGeorge Bundy, *Danger and Survival*, 203

[122] Charles A. Ziegler and David Jacobson, *Spying without Spies: Origins of America's Secret Surveillance System* (Westport, Connecticut: Praeger, 1995), 190-193.

[123] Frank Shelton, *Reflections of a Nuclear Weaponeer*, 4-7.

[124] http://www.atomicarchive.com/Docs/Hydrogen/SovietAB.shtml; Furer,114.

On learning of the Soviet detonation, Edward Teller said, *"It seems that the Russian rate of progress is at least comparable to, if it does not exceed, the rate of progress in this country."*[125] John Manley, a senior Los Alamos scientist, concluded that given American inability to predict Soviet success, United States policy should seek *"to strengthen our position as rapidly as possible and maintain a rate of progress limited only by our resources for a relatively long period of time."*[126] AEC Commissioner Lewis Strauss circulated a memo among his fellow commissioners proposing an expansion of the hydrogen bomb program, saying *"that the time has now come for a quantum jump in our planning … that is to say, that we should now make an intensive effort to go ahead with the Super."*[127] Strauss' memo *"sparked a secret debate within the government about whether or not to initiate a crash program to develop the hydrogen bomb."*[128] The debate centered on one seemingly crucial issue: *"Was or was not a high priority program for the development of the super bomb the appropriate response"* to the first Soviet bomb?[129] Senator Brien McMahon, now chairman of the Joint Committee on Atomic Energy, *"believed a crash program to develop the super"* was critically important.[130] Lilienthal and Oppenheimer disagreed. The nation's nuclear stockpile of fission weapons, they argued, was sufficient to protect the country. [131] Strauss asked his friend Sidney Souers, the executive director of the National Security Council, if Truman was aware of the Los Alamos work on hydrogen

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[125] Edward Teller, *To Technical Council Members*, LANL Archives, October 12, 1949.

[126] J. H. Manley, *To Members of the Technical Council,* LANL Archives, October 13, 1949.

[127] Lewis Strauss, *Men and Decisions* (Garden City, NY: Doubleday, 1962), 217.

[128] Dean Acheson, *Present at the Creation: My Years in the State Department* (New York: W.W. Norton, 1969), 344; Gordon Dean*, Forging the Atomic Shield*, 35

[129] Herbert York, *The Advisors: Oppenheimer, Teller and the Superbomb* (Stanford: Stanford University Press, 1976), 45; Lewis Strauss*, Men and Decisions*, 222.

[130] Dean Acheson, *Present at the Creation*, 344 – 346; Gordon Dean, *Forging the Atomic Shield*, 18.

[131] Herbert York, *The Advisors*, 56.

bomb. Souers didn't know and told Strauss he would ask Truman about it the next day. As Souers recalled many years later, *"I asked him [the President] if he had any information on it. He said, 'No, but you tell Strauss to go to it and fast."*[132] The "highest national power," the President of the United States, finally knew about the hydrogen bomb.[133]

Despite his words, Truman was initially content to let science and technology take their course until Senator Edwin Johnson, D-Col., said, during a television interview, that Los Alamos was working on a hydrogen bomb, Truman felt he needed to act and asked the NSC special subcommittee to reconvene and discuss *"whether and in what manner the United States should undertake the development and possible production of super atomic weapons … and whether and when any publicity should be given this matter."*[134] At the subcommittee's first meeting, Lilienthal opposed the hydrogen bomb on moral grounds. Such a bomb would kill too many people. Secretary of Defense Louis Johnson, echoing the unanimous view of the Joint Chiefs, supported its quick development.[135] Acheson slightly favored building the hydrogen bomb. He found Lilienthal's moral argument unpersuasive because regardless of what the United States might do, the Soviet Union would not delay their development of a super bomb. Equally compelling, said Acheson, *"the American people simply would not tolerate a policy of delaying research in so vital a matter."*[136] Given the lack of a unanimous opinion, the special committee's

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[132] *Sidney Souers Oral Interview*, Truman Library.

[133] Richard Hewlett, *The New World*, 374.

[134] Lewis Strauss, *Men and Decisions*, 222 and Dean Acheson*, Present at the Creation*, 346; McGeorge Bundy, *Danger and Survival*, 212.

[135] Omar N. Bradley, A *General's Life: An Autobiography by General of the Army Omar N. Bradley* (New York: Simon and Schuster, 1983), 515.

[136] Dean Acheson, *Present at the Creation*, 349.

first meeting ended without a recommendation. A second meeting was scheduled for January 31, 1950.

Anxious to bring the matter to a quick conclusion, Acheson prepared a set of four recommendations that he hoped both Lilienthal and Johnson would endorse.[137] The first recommendation called for the President to *"direct the Atomic Energy Commission to proceed to determine the technical feasibility of a thermonuclear weapon, the scale and rate of effort to be determined jointly by the Atomic Energy Commission and the Department of Defense."* The second recommendation gave the President the option of deferring the final development of the hydrogen bomb pending a possible reexamination *"as to whether thermonuclear weapons should be produced beyond the number required for a test of feasibility."* The third recommendation directed *"the Secretary of State and the Secretary of Defense to undertake a reexamination of our objectives in peace and war and of the effect of these objectives on our strategic plans, in the light of our probable fission bomb capability and possible thermonuclear bomb capability of the Soviet Union."* The fourth and final recommended that *"the president [should] indicate publicly the intention of this Government to continue work to determine the feasibility of a thermonuclear program, and that no further official information will be made public without the approval of the President."* [138]

Acheson presented his recommendations at the subcommittee's second (and last) meeting at 10:15 am on January 31, 1950.[139] Secretary Johnson objected to the wording of Acheson's second recommendation. He did not want any encumbrance placed on the production of weapons. After some debate, both Acheson and Lilienthal agreed to excise the paragraph. Once

[137] Ibid, 348.

[138] David E. Lilienthal, *The Journals of David E. Lilienthal,* Volume II, 624.

[139] Ibid.

this was done, all three committee members, including Lilienthal much to Acheson's' surprise, signed the recommendations. Lilienthal decided not to directly oppose Acheson and Johnson, choosing instead to register his personal reservations directly with Truman.[140] Undersecretary of Defense Stephen Early, a former presidential press secretary who attended this meeting, suggested that the President would be best served and the decisions would seem less ominous if his decision were announced in a press release rather than at a press conference. Accordingly, a draft press release was prepared for the President saying that as Commander-in Chief, he had *"directed the Atomic Energy Commission to continue its work on all forms of atomic weapons, including the so-called hydrogen or super-bomb."* It concluded that this work was and would continue to follow American objectives *"until a satisfactory plan for international control of atomic energy is achieved."*[141]

Secretary Johnson, who had a scheduled meeting with the President that day, suggested that the subcommittee use his appointment to report to Truman. *"The heat was on,"* said Johnson, *"and every hour counted in getting this matter disposed of."* At 12:35 pm, Acheson handed the President the subcommittee's report, which Truman started to read. Acheson also told Truman that Lilienthal wished to make a statement. Shortly after Lilienthal began expressing his misgivings, Truman cut him off, approved the recommendations, and said that further discussions were impossible since Senator Johnson had made the issue public. *"Further delay,"* said Truman, *"would be unwise."* Seven minutes after entering the Oval Office, the committee left. Later that day, Truman issued the prepared press release.[142] Truman spoke little of the

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[140] Dean Acheson, *Present at the Creation*, 349.

[141] David Lilienthal, *The Journals of David E. Lilienthal,* Vol. 2, 626-633; Dean Acheson, *Present at the Creation*, 348-349; and Harry S. Truman, *Public Papers 1950*, #26; and Harry S. Truman*, Years of Trial and Hope*, 309.

[142] In his memoirs, Truman does not mention Lilienthal's attempt to qualify his support, saying only that the recommendations were "unanimously signed".

hydrogen bomb after his January 31st press release.[143] In a news conference held on February 2nd, he effectively shut down all inquiries about his decision. However, the President did allow Acheson to make a quasi-public speech in February that reflected the administration's thinking. Noting that many people were *"rightly troubled"* by developing this *"new and very terrible weapon,"* Acheson argued that it meant only *"that we must be even more calm and even more steady than we have been in the past, because the responsibilities and the consequences of not being calm and not being steady are more terrible than they were before."*[144] Although Truman's press release is often thought to have had a profound impact on the nation's thermonuclear program, its impact, particularly on Los Alamos, was limited because the Laboratory already was working on the hydrogen bomb, as it had been since 1943.[145]

The First Thermonuclear Fire

Six months after the President's announcement, Gordon Dean, Lilienthal's successor as Chairman of the AEC, notified Truman of the need for a 1951 test series at Enewetak, codenamed Greenhouse, that might include a test involving a thermonuclear burn. As Dean told the President, *"We have every hope that our progress in research and planning during the coming months will justify our return to you at a later date to obtain formal approval for this test operation."*[146] Greenhouse, however, nearly became a casualty of the Korean conflict. As United States military involvement in Korea expanded throughout the latter half of 1950, the JCS seriously considered postponing or cancelling the test series. Bradbury took strong exception,

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[143] Harry S. Truman, *Public Papers*, 1950, #29.

[144] Dean Acheson, *State Department Bulletin*, *Vol. 21*, 274.

[145] The one visible change was a return to a six-day work week, a practice stopped at the end of the war.

[146] Gordon Dean to the President, LANL Archives, July 17, 1950. Although Enewetak was not suitable for "frequent real tests," the atoll was still useable for the relatively infrequent high yield tests, those generally greater than 50 kilotons.

telling Brigadier General James McCormack, Director of the AEC's Division of Military Application, that it did not make sense that the Greenhouse tests be delayed or cancelled at *"precisely a time in international relations, when the most rapid progress should be made in this [thermonuclear] field."* Bradbury went on to tell McCormack that while Los Alamos recognized the good intentions of the Chiefs of Staff, *"it is now not quite clear to us why Eniwetok seemed such a fine idea since it has become embarrassingly obvious that, just as one wants and needs it most, and just as the program is accelerated, the chances of using it decrease alarmingly."* [147] In the end, the quest for a hydrogen bomb carried the day, and Greenhouse was conducted.

Table 3
Operation Greenhouse

Test Codename	Date	Island	Yield (kt)
Dog	04/07/1951	Runit	81
Easy	04/20/1951	Engebi	47
George	05/08/1951	Ebiriru	225
Item	05/24/1951	Engebi	45.5

Despite JCS concerns, Greenhouse was conducted without incident. The first two Greenhouse shots, Dog and Easy, were vastly improved implosion devices. At 81 kilotons, Greenhouse-Dog was the largest yield fission device to date. The third test, the George shot, ignited the world's first thermonuclear fire, leading directly to the Mike shot a little over a year later.[148] As Jay Wechsler, a Los Alamos weapon engineer said, *"The George shot, the design of which resulted from the crash program on the H-Bomb, confirmed that our understanding of the*

[147] N. E. Bradbury to McCormack, LANL Archives, 22 August 1950.

[148] Atomic Energy Commission, *Draft Report to the President on the Status of Thermonuclear Program*, LANL Archives, February 26, 1951.

means of initiating a small-scale thermonuclear reaction was adequate."[149] The final test, the Item shot, proved the principle of boosting. Of all the technical developments that led to the creation of the hydrogen bomb, the development of a fission device energetic enough to light a thermonuclear fire, as Hans Bethe has written, was underappreciated. Without a fission device of sufficient energy, the hydrogen bomb was not possible. While the explosive yield of fission devices could be increased, in theory to a megaton, such increased yields could only be achieved by significantly increasing the amount of nuclear fuel making any such device very large, inherently unsafe, and of no practical value. The answer to achieving increases in yield without consuming exorbitant amounts of nuclear material was to use a technique called "boosting," the use of *"a fission bomb to initiate a small thermonuclear reaction that, in turn, increases the efficiency and use of the fissile material."*[150] Item's yield, although small in relation to the other Greenhouse shots, was easily double that of its non-boosted version and insured a fission device energetic enough to light a hydrogen bomb.

Despite the success of both the George and Item tests, the problem of the Inverse Compton Effect remained. A thermonuclear fire could be ignited but could not be sustained. The answer to this persistent problem came to Edward Teller in a fit of anger. While stewing over the needling of a colleague, it suddenly occurred to him that the radiation produced by atomic bombs had mass that could be channeled and used to compress deuterium, thereby enhancing and sustaining a thermonuclear reaction capable of overcoming the Inverse Compton Effect. The concept of radiation implosion, which is the basis for all modern thermonuclear weapons, was discovered. Using this discovery, the design of the first test of a full-scale thermonuclear device, codenamed Mike, was completed in June 1952.

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[149] *Los Alamos Science, Winter/Summer 1983*, 159-163.

[150] Herbert York, *The Advisors*, 23 and Carson Mark, "*A Short Account*", 9.

Truman authorized Mike's proof test on September 10, 1952, with a firing date of November 1st. Bethe and Oppenheimer proposed postponing the test *"so that irresponsible elements could not use it in a last-minute attempt to influence the election,"* Truman, let it be known that he hoped *"that technical problems would delay the shot."* Dean dispatched fellow AEC Commissioner Eugene Zuckert to Enewetak to find out if Mike could be reasonably postponed. The answer came back that any delay risked losing the prevailing winds, increased the risk of exposing nearby populations to radioactive fallout, and substantially increased the costs of maintaining thousands of personnel and hundreds of naval vessels and aircraft in a state of readiness. Truman did not change the date. Mike was fired as scheduled.[151]

Table 5
Operation Ivy

Test Codename	Date	Island	Yield (kt)
Mike	10/31/1952	Elugelab	10,400
King	11/15/1952	Airdrop over Runit	500

[151] Gordon Dean, *Forging the Atomic Shield*, 202-203; Eugene Zuckert Oral History, Truman Library.

Figure 19. Mike shot cab shown in far background. LANL Archives.

Figure 20. Mike device along with test personnel. Marshall Holloway is third from the right. LANL Archives.

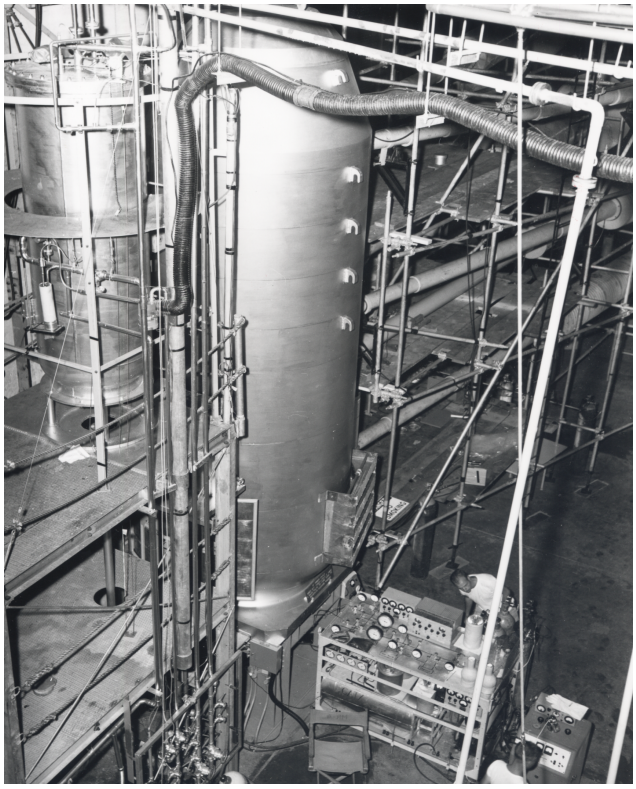

Figure 21. Mike device just prior to its detonation. LANL Archives.

The dark glasses worn by Reed Hadley, and everyone else topside on the USS Estes, protected them against flash blindness. Even from a distance of fifty miles, Mike's brilliance was more than the human eye could withstand. Once the brilliance subsided and the glasses taken off, Hadley and his shipmates saw Mike's mushroom rise to over 100,000 feet, well into the stratosphere. Mike was a stunning success. Hours later, observers flying in helicopters found only deep blue water where the island of Elugelab had once been. Not only had Mike vaporized Elugelab, the explosion also dredged a crater over 200 feet deep. The dark blue water of the new crater contrasted sharply with the surrounding shallow, green water of the lagoon.

Two weeks later the highest yield fission device detonated by the United States, King, was detonated high over the island of Runit. King, capable of being scaled up to a megaton yield, was intended to provide the United States with a very high yield nuclear weapon should Mike

fail. Although the test was successful, King was unwieldy, inherently unsafe, and, after Mike, unnecessary. It was quickly forgotten.

Truman and Los Alamos

The quest for the hydrogen bomb is notable primarily for the political angst generated and sustained by early Cold War paranoia. One of the outcomes of this paranoia was the pillorying of America's most famous scientist, J. Robert Oppenheimer, whose career was sundered. Although the development of the hydrogen bomb was a politically charged, issue, reality was quite different. As Truman's Assistant Press Secretary, Eben Ayers, recorded in his diary on February 3, 1950, *"The President said there actually was no decision to be made on the H-Bomb, we have got to have it if only for bargaining purposes with the Russians."*[152] And, according to General of the Army Omar Bradley, Truman had already made up his mind before the NSC special subcommittee presented its report to the President. Bradley, who met privately with the President on three occasions in January to discuss the hydrogen bomb, recalled in his memoirs: *Truman was deeply troubled because AEC Chairman David Lilienthal was a humanitarian whom Truman greatly respected. But Truman had a way of seeing things clearly and going to the heart of the matter. If the Russians proceeded with the H-Bomb and we did not, and it worked, we would find ourselves in an intolerably inferior military posture. To Truman, it was as simple as that.* As subsequent events revealed, the Soviet Union was indeed developing the hydrogen bomb and, in fact, designed, built, and tested such a weapon before the United States.[153]

[152] Richard Rhodes, *Dark Sun*, 407. Omar N. Bradley, *A General's Life*, 517

[153] See Richard Rhodes, *Dark Sun*; David Holloway, *Stalin and the Bomb: Making the Russian Bomb*; *Harold Agnew Oral Interview,* LANL Archives; and Frank Shelton, *Reflections of a Nuclear Weaponeer*, 1-10.

For Bradbury and Los Alamos, the hydrogen bomb was always a physics problem, albeit one of immense complexity. As Bradbury recalled in a 1969 letter to Congressman Chet Holifield, Chairman of the Joint Committee on Atomic Energy, *"I opposed the "crash program" urged by Edward Teller partly because the words meant very little in a practical sense, partly because diffuse, random, and frantic effort would probably waste time and money and delay real accomplishment, and partly because the only way that anyone at the time could think of going showed little or no chance of providing a remotely useful weapon."*[154]

The Marshallese

The hydrogen bomb was bad news for the Marshallese. Mike vaporized Elugelab, along with chunks of two other islands and spread radioactive fallout over the northern islands of the dri-Engebi tribe, whose repatriation was now very unlikely. The sheer size of Mike's energy yield immediately rendered Enewetak Atoll too small to continue as America' sole Pacific test site. Bikini, long forgotten, was reactivated for the 1954 Castle tests. When very little fallout from Mike was detected, it was assumed that the radioactive debris was trapped in the stratosphere by the temperature inversion between the tropopause and the stratosphere, a theory known as stratospheric trapping. When the first test of the Castle test series, Bravo, disproved this theory, it was too late for the people of Rongelap Atoll, who were physically injured by Bravo's fallout. The Rongelap people were forced into exile, a condition that remains today.

[154] Bradbury to Holifield, LANL Archives.

Chapter 6: Why Buy a Cow When Powdered Milk is So Cheap?

At 6:45 am local time on February 28, 1954, the thermonuclear test device codenamed Bravo erupted from a small, manmade sandspit on Bikini Atoll with a force of fifteen megatons. Within seconds, Bravo's blast wave swept over the entire atoll destroying and contaminating everything in its path. The six-man firing party, housed in a steel and concrete bunker nearly thirty miles from ground zero, became seasick because their bunker moved as if riding on ocean swells.[155] Unexpectedly, Bravo's radioactive fallout rained down on Rongerik, Rongelap, and Utirik Atolls, forcing emergency evacuations of each atolls' inhabitants.[156] News of these evacuations barely caused a ripple in Washington. However, all hell broke loose when, on March 16th, the Associated Press reported that radioactive debris from Bravo had fallen on a Japanese fishing trawler, ironically named the Lucky Dragon. The Japanese people were instantly reminded of the horrors of Hiroshima and Nagasaki. Bravo, the most successful and highest yield of all United States nuclear tests, became, as well, the nation's most problematic, intensifying a growing worldwide concern about radioactive fallout.

[155] Bernard J. O'Keefe, *Nuclear Hostages* (Boston: Houghton Mifflin, 1983), 189. The firing party made a mad dash to hovering helicopters when radiation levels dropped enough to risk the attempt.

[156] Rongerik was temporarily inhabited by twenty-six armed forces personnel conducting weather reconnaissance for Castle.

Figure 22. Bravo test stand.

Figure 23. Bravo device inside the concrete shot cab. LANL Archives.

Emergency Capability

In May 1952, well before Mike, Norris Bradbury told the local AEC oversight office that the Laboratory might include a thermonuclear test as part of its planned 1954 test series, codenamed Castle.[157] The AEC office immediately protested saying that such a test would be both too excessive and too expensive. Darol Froman reminded the AEC office that because official United States policy, as enunciated by President Truman, was *"to make progress as rapidly as possible in the thermonuclear field … it would appear most illogical to limit test activities for budget reasons because these activities have proven remarkably successful in the desired progress."*[158] The debate, however, became moot when the Department of Defense, in the wake of Mike, issued a national military requirement for *"a capability in thermonuclear weapons in early 1954."* Codified in the little-known Emergency Capability Program (ECP), the DoD requirement was not unwelcome news for either the AEC or Los Alamos. AEC Acting Chairman, Henry Smyth, told the Military Liaison Committee that Mike's *"behavior leads us to believe that adaptation of its design to a weapon or weapons offers real promise,"* although that adaptation*, "involves a great amount of engineering and process development and testing."*[159] Los Alamos scientists were especially confident. Even without a proof test, noted Los Alamos mathematician Carson Mark, an ECP weapon could be produced.[160] Norris Bradbury told the AEC's Director of Military Applications that *"only non-known characteristics of any such device will prevent its delivery by existing aircraft in time of war."*[161]

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[157] N. E. Bradbury to Carroll Tyler, LANL Archives May 8, 1952. The original Castle operation plan called for tests of "3±1" fission devices.

[158] D. Froman to H. Kraker, LANL Archives, May 24, 1952.

[159] H. D. Smyth to Robert LeBaron, Chairman, Military Liaison Committee, LANL Archives, January 2, 1953.

[160] Carson Mark to Alvin Graves, LANL Archives July 6, 1953.

[161] N. E. Bradbury to K. E. Fields, LANL Archives, 20 February 1953.

Both Mark and Bradbury were correct. Los Alamos produced a deliverable ECP device in late 1953, well ahead of schedule. The weapon and its delivery vehicle, the massive B-36, were logistical nightmares. If required for a combat mission against the Soviet Union, this first ECP bomb would be filled with its thermonuclear cryogenic fuel and loaded on B-36 bomber stationed at Kirtland Air Force Base in Albuquerque, New Mexico. Since Albuquerque's mile-high elevation prevented a fully fueled B-36 from taking off while carrying this very heavy weapon, the partially fueled bomber would make a short flight to Roswell, New Mexico, to fill up before making a long flight to Limestone, Maine. At Limestone, both the bomber and bomb would be refueled (the bomb's cryogenic fuel boils off over time). A third and final refueling stop had to be made at Thule, Greenland, before the bomber would enter Soviet territory. Retired shortly after the completion of Operation Castle, this first ECP device had the shortest stockpile life of any United States nuclear weapon. The B-36, both slow and cumbersome, would be gone in four years. The ultimate impact of the ECP, however, was not the weapon, but the fact that developing thermonuclear weapons became the single focus of Operation Castle.[162]

Bikini - Again

By 1951, it was evident that Enewetak could not long continue as the sole Pacific test site because the available real estate for ground zero locations was being consumed or contaminated at a rate that could not be maintained. Further, as Graves noted, the permanent facilities located on the southern perimeter of the atoll, were *"an important asset to the AEC and to the country and we will risk its loss to us if we continue to use up its real estate for tests."*[163] JTF Commander Major General Percy Clarkson, suggested using Ujelang Atoll saying, *"I believe the most serious consideration should be given to detonating Castle on UJELANG Atoll, Bikini, or*

[162] Ed Kemp, unpublished manuscript, author's archive.

[163] A. Graves to N. E. Bradbury, LANL Archives, 20 June 1952.

elsewhere. The problem at UJELANG involves the relocation of 158 natives, but I do not believe this to be an insurmountable obstacle." As for Bikini, Clarkson, with unintended prescience, stated *"There is a rad-safe hazard to the following inhabited civilian communities in the vicinity of BIKINI: Rongelap 112 inhabitants, Utirik 178, Wotho 30."*[164] Graves thought otherwise , telling Bradbury that *"although I am not yet ready to recommend that Bikini be reactivated to a sufficient extent to permit some tests to be done on that Atoll, I believe the Laboratory should take the position that it may so recommend in the near future and strongly oppose any decision which might jeopardize that possibility, such for example as the return of the natives to that Atoll."* Bradbury concurred and notified the AEC that *"a preliminary investigation of the cost of reactivation of Bikini for one or more Castle shots had been begun."* [165] By August 1952, it was all but certain that Bikini would once again be used. Carroll Tyler, the AEC oversight manager of Los Alamos, told Brigadier General Kenneth Fields, the Director of the AEC's Division of Military Applications, that useable real estate was the driving issue in wanting to reactivate Bikini and that alternative Marshallese sites, such as Taka, Bikar, and Taongi Atolls, had been evaluated and quickly dismissed because of a lack useable land area. Another possibility according to Tyler was Rongerik, which had sufficient real estate, but was too close to Rongelap. Tyler, like Clarkson, noted that *"any large-scale detonations at Rongerik would almost certainly require evacuation of the natives from Rongelap and might even contaminate that area so as to restrict return of the Rongelap people."* Bikini, Tyler failed to note, was in the same neighborhood and presented the very same problems.[166]

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[164] P. Clarkson to A. Graves, LANL Archives, 26 May 1952. By this time, the Bikinians had been moved to Kwajalein. Clarkson did not mention, although everyone knew it, that the natives of Ujelang were the Enewetak people.

[165] A. Graves to P. Clarkson, LANL Archives, 11 June 1952; and A. Graves to N. E. Bradbury, LANL Archives, 20 June 1952.

[166] C. Tyler to K. E. Fields, *Selection of Alternative Site for Castle*, LANL Archives, August, 27, 1952.

What made Bikini, judged unsuitable for testing after Crossroads, useable for the planned megaton-yield Castle devices? First, Bikini was relatively close to Enewetak (130 miles). Enewetak's extensive logistical facilities could easily support testing on Bikini. Test devices, for instance, could be assembled at Enewetak and floated to Bikini on barges, thereby eliminating the need for a second support facility. Second, most of the Castle test devices would be detonated on barges anchored in Bikini's lagoon thereby eliminating the need for real estate.[167] Third, the atoll was uninhabited, albeit because the Bikinians had not been allowed to return home after Crossroads. The AEC exploited this last condition when Tyler bluntly told Fields that Bikinians were not an issue in the discussion of testing. Although he had received two conflicting reports about the Bikinians, Tyler was adamant that *"Bikini is most suitable as to land area and location."*[168] The Bikinians, said Tyler, should be told that the they can never return to that atoll.[169] Thus, Bikini became the site of five thermonuclear tests conducted during Castle.[170]

Table 5
Operation Castle

Test Codename	Date	Atoll	Yield (kt)
Bravo	02/28/1954	Bikini	15,000
Romeo	03/26/1954	Bikini	11,000
Union	04/25/1954	Bikini	6900
Yankee	05/04/1954	Bikini	13,500
Nectar	05/13/1954	Enewetak	1690

Bravo

[167] An additional benefit to using barges was that seawater contains relatively little particulate matter, thereby reducing radioactive fallout.

[168] One report characterized the Bikinians as being "unable to sustain themselves" on Kili. The second said, "They were content with their current locations and, in fact, 'never had it better.'"

[169] C. Tyler to K. E. Fields, *Selection of Alternative Site for Castle*, LANL Archives, August, 27, 1952.
The Bikinians, in 1956, signed an agreement giving their atoll to the United States. The agreement was eventually abrogated and some Bikinians were allowed to return in 1967. They left again when their body burdens of radionuclides rose to levels of concern.

[170] A sixth test was conducted at Enewetak.

Bravo's towering mushroom cloud provided more than enough evidence that the test was a startling success. An experimental design, Bravo was added to the Castle shot schedule after a young weaponeer, Harold Agnew, argued, that Los Alamos should *"consider, in the light of new developments, the reasonableness of the overall [thermonuclear] endeavor."*[171] One of those new developments was the use of a dry (and cheaper) thermonuclear fuel rather than the high maintenance cryogenic fuel of Mike. Agnew knew that his proposal was likely be ignored by senior Laboratory managers unless someone of great influence cosigned his proposal. That person was Hans Bethe, arguably one of the most respected physicists in the world. Since Bethe could not be ignored, Bradbury added Bravo to the Castle shot schedule. As he watched Bravo's mushroom cloud climbed into the sky, Agnew sent a teletype to Bradbury saying, *"Why buy a cow when powdered milk is so cheap?"* Agnew meant, of course, that cheaper dry thermonuclear fuel worked as well as expensive wet, cryogenic fuel. Even as Bravo's mushroom cloud was rising, all work on cryogenic weapon systems was stopped. In the blink of eye, Bravo changed the course of thermonuclear weapons development.[172].

[171] H. M. Agnew and H. A. Bethe to N. E. Bradbury, LANL Archives, August 19, 1953

[172] One of the oddest occurrences of any test operation occurred when Bravo's fallout contaminated two work camps on Bikini. The work crews of these two camps were temporarily moved to ships for the detonation. Since their stay on ships was to be brief, they were ordered to leave most of their belongings in camp. Bravo, of course, destroyed or contaminated everything left behind, including clothing. Restitution was slow in coming. No one, it was determined, had the authority to make restitution. Only after Bradbury insisted, was restitution made – if each worker submitted a detailed list of lost clothing. Even as millions of dollars was being spent conducting Operation Castle without qualm, the anxiety about reimbursing a few hundred dollars for clothing reached all the way back to Los Alamos and even Washington, D.C.

Figure 24. Castle Bravo. LANL Archives.

Figure 25. Tare work camp prior to Bravo. LANL Archives

Figure 26. Tare work camp after Bravo. LANL Archives

Nearly a month elapsed before the second Castle test could be conducted. The delay was caused by the emergency evacuations of Rongerik, Rongelap, and Utirik (the subject of the next chapter); unsettled weather conditions, particularly wind patterns; and the fact that Bravo made the design of the next scheduled test device, Yankee, a wet device, obsolete. Los Alamos substituted another dry device, Romeo in Yankee's place. Detonated on March 26th, Romeo's yield, an impressive yield of eleven megatons, further validated dry fuel thermonuclear systems. Eleven days after Romeo, the University of California Radiation Laboratory (UCRL) conducted the first of its two planned thermonuclear tests, Koon, which failed to give a megaton yield. Koon was, in thermonuclear terms, a failure. The second UCRL test was cancelled because that device was of the same general design as Koon. On April 25th, Los Alamos fired Union, which had a yield of nearly seven megatons. Yankee, now reconfigured as a dry device, was fired on

May 4th giving an impressive yield of 13.5 megatons. The last Los Alamos test, Nectar, a lower yield device, was fired on May 13th.

Figure 27. Castle Romeo. LANL Archives.

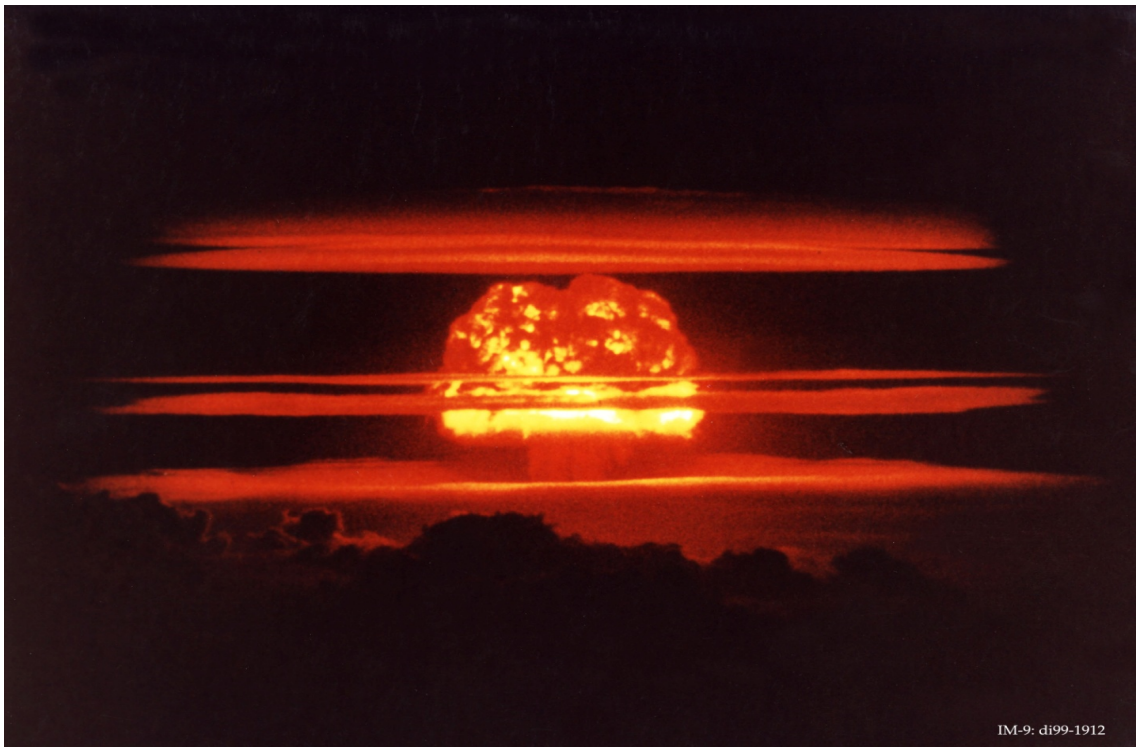

Figure 28. Castle Union. LANL Archives.

Figure 29. Castle Yankee. LANL Archives.

The Thermonuclear Learning Regime

Technically, Castle was a tremendous success. Each Los Alamos test validated a design that could quickly be weaponized and placed in the national stockpile. While good technical news, the unexpected high yields also meant that Los Alamos did not yet fully understand thermonuclear reactions. Future tests would have to be conducted to resolve the differences between predicted and actual yields. For the UCRL, Castle was an embarrassment. Koon's failure sent the UCRL back to the nuclear drawing board. Two years later, the UCRL would field several successful devices during Operation Redwing.

Environmentally, Castle was a disaster. The phenomenology of fallout from thermonuclear tests was not well characterized. The theory of stratospheric trapping, accepted without experimental proof, and generalized without question to include all thermonuclear detonations, was disproved by Bravo. Bravo's fallout injured many Marshallese and severely contaminated the atolls of Rongelap, Rongerik, and Utirik; the Japanese fishing trawler, the Lucky Dragon; and even ships of the Castle task force. When Bravo disproved the theory of stratospheric trapping, radioactive fallout became a worldwide issue; one that made testing in the atmosphere an issue the world could not ignore.

Castle also brought an end to the design era of nuclear weaponry. During this era, the constructs of fission and fusion were given physical form by Trinity, Mike, and Bravo. Because Mother Nature does not have any more nuclear secrets like fission and fusion to discover, nuclear weapons, after Castle, became commodity items, refinements and variations of what came before. The final two test series conducted in the Marshall Islands, Redwing and Hardtack I, characterized the new era.

Chapter 7: "THE WORLD, WE THINK SHE START OVER AGAIN"

The USS Philip, a destroyer escort on security patrol around Bikini, was unexpectedly detached from its duty station on March 2nd and ordered to Rongelap Atoll, reaching its destination in the early morning of March 3rd. A representative of the Trust Territory was waiting for the Philip, having flown to the atoll by PBY floatplane to legally authorize, if necessary, the evacuation of the atoll's people. When high levels of radioactive contamination were confirmed, both the atoll's Iroij, John, and the Trust representative agreed to an immediate evacuation. Sixteen persons, ranging in ages from six to eighty-three, deemed too old or too sick for transport by the Philip, were placed aboard the PBY and flown to Kwajalein. The remaining forty-eight natives were ferried to the Philip by whaleboat. Each person was allowed only a small handbag with a few personal belongings. Had the theory of stratospheric trapping been accurate, Bravo's radioactive debris would not have fallen on Rongelap.[173] But, instead, debris fell out over a wide area that included several inhabited atolls, ships of the JTF task force, and on the Lucky Dragon. Bravo's radioactive fallout was not an issue until the Japanese press broke the story about the Lucky Dragon's exposure. As a result, Bravo's fallout became an international issue. All of this happened, said Alvin Graves, because *"the theory of stratospheric trapping has not been substantiated by the facts of Bravo."*[174]

Nuclear Detonations and Fallout

The amount of fallout produced by a nuclear detonation is primarily determined by the size of the energy yield in combination with the environment surrounding the test device. Explosions with energy yields up to 500 kilotons, if detonated on or close to the earth's surface,

[173] Changing wind directions played a part in dumping fallout on Rongelap, but the key factor was the faulty theory of stratospheric trapping.

[174] Alvin Graves to Norris Bradbury, LANL Archives, 10 March 1954.

vaporize tens of thousands of tons of debris and lift that debris to varying heights in the troposphere, usually no greater than 30,000 feet. Debris injected into the troposphere travels at the latitude of the detonation with heavier contaminates falling out rather quickly. Explosions with energy yields above 500 kilotons, if detonated at or near the surface, inject millions of tons of radioactive debris into both troposphere and the stratosphere, typically above 60,000 feet. Among this debris are the radioactive isotopes ^{90}Sr and ^{137}Cs, which are threats to human health because they can cause cancer. ^{137}Cs is soluble in water and can quickly spread to soft tissue, where it continuously deposits both beta and gamma radioactivity.[175] ^{90}Sr is a bone seeker and, like ^{137}Cs, continuously deposits beta radioactivity. These radioactive isotopes are at the heart of the evacuations and why Rongelap is still uninhabitable.

Figure 30. Map showing atolls evacuated after Bravo. LANL Archives.

Evacuations

[175] Beta particles are high speed electrons emitted by the radioactive decay of an unstable isotope like ^{137}Cs. Los Alamos National Laboratory, *Radiological Worker Training Guide*, August, 1999.

The first indication of a radiological problem came at 3:00 pm on March 1 local time, a little less than nine hours after the detonation, when the needles of the radiation detection instruments on Rongerik Atoll went off scale.[176] At the same time, many of the Task Force ships, particularly the aircraft carrier Bairoko, reported radioactive fallout. Rongerik, normally uninhabited, was the temporary home of twenty-six military and two civilian support personnel maintaining the weather and radiation recording stations. A task force radiation officer flew to Rongerik aboard a Navy PBY flying boat to assess the situation. The officer quickly confirmed the existence of high levels of contamination and the need to evacuate the twenty-eight men. Acting on his own initiative, the radiation officer used his PBY to evacuate the men to Kwajalein, where their medical situation could be evaluated. The evacuation took place in two waves and was completed thirty- five hours after Bravo's detonation. Alarmed by the presence of fallout on Rongerik, the JTF ordered aerial monitoring of Rongelap Atoll, which lay directly between Bikini and Rongerik. When high levels of radioactivity were discovered, the JTF ordered the evacuation of Rongelap.

Aboard the USS Philip, the Rongelapese men and women were segregated. Marshallese women, modest by culture, were especially nervous in their new surroundings. Everyone showered to wash off as much external radioactivity as possible. Clothes were collected and laundered for the same reason. The Philip's crew donated personal clothing to replace garments that could not be decontaminated. Immediately after undergoing decontamination, the children were given milk. A bit later, the Marshallese went through the ship's mess line. As the Phillip's captain later reported, *"The meat course was the least popular. The majority asked for more soup, bread, and vegetables. Hot soup was most in demand. Ice cream was the natural favorite of the children."*[177] Before the Philip set sail for Kwajalein, eighteen additional Rongelapese,

[176] The data from these detectors was remotely collected and analyzed at an AEC laboratory in New York State.
[177] *The Evacuation of Rongelap and Ailinginae Atolls on 3 March 1954*. LANL Archives.

fishing in the lagoon of nearby Ailinginae Atoll, were located and brought aboard the Philip. Once this second group was boarded, the Philip left for Kwajalein, arriving at 8:30 am on March 4th, nearly seventy-two hours after Bravo's detonation. *"The Marshallese,"* the Philip's commander wrote, *"were excellent passengers, most cooperative, never demanding, and exemplary in conduct."* The evacuation of Rongelap created a third Marshallese Diaspora, one that continues today.[178]

When aerial monitoring confirmed high levels of radioactivity on a third atoll, Utirik, a second destroyer escort, the USS Renshaw, was dispatched to evacuate the atoll. The Renshaw, sailing from Enewetak, arrived on the morning of March 4th, and was also was met by a Trust Territory official.[179] Radiation readings confirmed the need to evacuate the islanders. Because the Renshaw could not navigate the entrance to the atoll's lagoon, the evacuation took place over the open ocean. The 154 natives of Utirik, beginning with the women and children, were loaded on rafts, floated over a reef, and then transferred to whale boats capable of reaching the Renshaw's anchorage. Wind and waves hampered the evacuation nearly capsizing two rafts. Still, all of the natives were aboard the Renshaw in just over two hours, leaving behind the most *"forlorn set of dogs as you have ever seen."*[180]

Immediately after setting course for Kwajalein, the crew of the Renshaw fed their new passengers meat loaf, bread, mashed potatoes, and oranges. The meat loaf went untouched. The Utirik people were not as comfortable as the Rongelapese when it came to decontamination. It was a struggle to get them to take showers. The islanders ate a supper of boiled fish and rice

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[178] Ibid.

[179] Lt. Colonel Richard A. House, USAF, *Radsafe Narrative of Events*, LANL Archives.

[180] *Report of Evacuation of Natives, Utirik Atoll,* LANL Archives, 4 March 1954.

followed by ice cream and cookies. After an uneventful night, they ate a large breakfast of hot cakes and bacon before arriving at Kwajalein. The Renshaw's captain wrote of his passengers as they disembarked, *"As they went over the side one could not help but observe and admire the innate dignity of these simple human beings and their naïve but forthright and optimistic attitude toward life."* When asked what he thought of his situation, the Utirik Iroij replied, *"The world, we think she start over again."*[181]

A week after the evacuations, a third destroyer escort, the USS Nicholas, carried a radiological survey team to the evacuated atolls. A Trust Territory representative met the Nicholas at both Rongelap and Utirik to oversee and authorize all actions involving native property. On both Rongelap and Utirik, the survey team conducted radiological assessments and collected water and soil samples. Houses were secured to prevent damage by weather and roaming livestock. Food was dumped outside as feed for the chickens and pigs. Everything that could hold water, even clamshells, was filled with water. Dogs and cats were killed since they were a menace to the islanders' chickens. At Rongerik, all food was dumped in the ocean and each piece of equipment packed and placed aboard the Nicholas.[182] The Nicholas returned again to Rongelap on March 25th to conduct a more in-depth radiological survey of the atoll including the collection of soil, fruit, and vegetation specimens. The survey crew also captured six pigs and five chickens that would later be examined for signs of internal contamination. The lone boar, too big to capture and transport, was killed and autopsied. The planned capture of wild rats was abandoned because of the need to leave Rongelap well ahead of the Romeo test, which was

[181] Ibid.

[182] *Radsafe Survey 8-11 March 1954*; LANL Archives.

scheduled for the next day. The specimens collected on Rongelap confirmed that the atoll was seriously contaminated and could not be reoccupied in the near future.[183]

Complications

The evacuations did not cause any immediate or apparent anxiety in Washington. General Kenneth Fields, the AEC's Director of Military Applications, told Clarkson and Graves that although he anticipated *"being pressed by higher authority for an explanation regarding the circumstances that led to the exposures of the natives, and why they were not evacuated in advance,"* no one seemed particularly worried about the situation.[184] In fact, no public announcement was even planned. Alvin Graves immediately protested, sending a strongly worded "eyes only" teletype to Fields specifically noting that the Soviet Union had dissented from the UN approval for the evacuation of the Enewetak people in 1948 and were presumably monitoring the current situation. *"I should regret very much*," Graves said, *"the impression that we are being furtive in our actions with regard to these people."*[185] Fields did not respond to Graves but, on March 11th, told Clarkson that the following statement had been released to the press:

> *During the course of routine atomic tests in the Marshall Islands, 28 U.S. Personnel and 236 residents were transported from neighboring atolls to Kwajalein Island according to plans as a precautionary measure. These individuals were unexpectedly exposed to some radioactivity. There were no burns. All reported well. After completion of the atomic tests, they will be returned to their homes.*[186]

This statement was both disingenuous and inaccurate beginning with the characterization of the tests as *"routine."* Bravo was not routine, its design speculative and its expected yield grossly

[183] *Report of Rongelap Survey Trip 25-26 March 1954*; LANL Archives.

[184] TWX, Fields to Clarkson, LANL Archives, March 5, 1954

[185] TWX, Graves to Fields, LANL Archives, March 5, 1954.

[186] TWX, Fields to Clarkson, March 11, 1954

miscalculated. The most disingenuous statements, however, were the characterizations of the evacuations as a *"precautionary measure"* and that there were *"no burns."* The evacuations were not precautionary, but emergencies. The level of contamination from prolonged exposure was serious. Especially disingenuous was the statement about the absence of burns since, as was found during Sandstone, they do not manifest themselves immediately.

The press release generated little public interest. Then, on March 16th, the Japanese press reported that a Japanese fishing trawler, the ironically named No. 5 Fukuryu Maru (The Lucky Dragon), and its crew had been contaminated by Bravo's fallout. The Lucky Dragon had sailed undetected to within eighty miles of Bikini on the morning of March 1st, when *"the skies in the west lighted up and a great flare of whitish yellow light splashed against the clouds and illuminated the water,"* as if *"the sun rose in the west."* A short time later, the ship's crew reported that *"the ship seemed to tremble as though shaken from below and a great sound wave enveloped the ship, seeming to come at once from above and below."* About two hours after the detonation, falling ash began accumulating on the deck of their ship. One crewman likened it to a snowstorm, with footprints visible on the exposed deck.[187] By the time the Lucky Dragon returned to Japan on March 14th, its crew exhibited the classic symptoms of radiation sickness - vomiting and hair loss. After examination by a local doctor, the crew was quarantined and later transferred to a Tokyo hospital. A reporter for the *Yomiuri Shimbun,* hearing rumors that the Lucky Dragon had been exposed to radioactivity, investigated the incident and broke the story in the paper's March 16th morning edition.[188] As the newspaper *Asahi Shimbun* subsequently commented, the Japanese people were *"made to feel acutely once again the horrors an atom*

[187] Ralph E Lapp, *The Voyage of the Lucky Dragon: An Extraordinary Sea Story* (New York: Harper and Brothers Publishers, 1957), 28-35.

[188] Ibid, 78.

bomb."[189] Tensions increased when one American scientist publicly stated that Japanese doctors were *"not well equipped to deal properly with the radiological aspect of the problem."*[190] This same American scientist also failed to mention was that there was no treatment for radiation exposures, other than to guard against infection. Ultimately, one of the Lucky Dragon's crewmen died from an unidentified cause. The Japanese believed it to be from radiation.

Both the domestic and foreign Japanese tuna markets collapsed when millions of Japanese immediately stopped buying the fish and the United States imposed strict radiation monitoring standards on tuna imports.[191] The industry suffered even more when the United States expanded the exclusion zone around the Marshall Islands to prevent a repeat of the Lucky Dragon incident. Japan's tuna fleet of 300 boats hauling sixty-five percent of the annual tuna catch now had to make lengthy detours that added days to their voyages, substantially increasing costs. When Japan complained about the enlarged exclusion zone, a tone-deaf Clarkson replied, we, JTF-7, *"believe that the importance of atomic tests to our atomic weapon program and to national security are such that tests should be conducted when our scientific laboratories desire them to be conducted."*[192] The feeling of Japan and its people was summed up by a protest

[189] TWX, DMA to Bradbury, LANL Archives, March 16, 1954.

[190] Merril Eisenbud to John C. Bugher, MD, *Contamination of the Fukuryu Maru and Associated Problems in Japan: A Preliminary Report, ca, April 1957*; TWX C-118, DMA to Bradbury, March 16, 1954; TWX C-120TWX, DMA to Bradbury, March 16, 1957; TWX, USAEC to CJTF-7, March 31, 1954; and TWX, CJTF-7 to AEC, April 2, 1954. LANL Archives; and Spencer R. Weart, *Nuclear Fear: A History of Images* (Cambridge: Harvard University Press, 1988), 185-186.

[191] Spencer R. Weart, *Nuclear Fear: A History of Images*, 186. Author's note: Parents even kept their children from swimming in the Pacific.

[192] Merril Eisenbud to John C. Bugher, MD, *Contamination of the Fukuryu Maru and Associated Problems in Japan: A Preliminary Report, ca, April 1957*; TWX C-118, DMA to Bradbury, March 16, 1954; TWX C-120TWX, DMA to Bradbury, March 16, 1957; TWX, USAEC to CJTF-7, March 31, 1954; and TWX, CJTF-7 to AEC, April 2, 1954. LANL Archives.

banner, which said, *"It doesn't take a bullet to kill a fish seller. A bit of Bikini ash will do the job."*[193]

The Lucky Dragon incident also heightened worldwide awareness and fear of radioactive fallout. Bravo's fallout created a sense of vulnerability as people struggled *"to understand the perils of the H-bomb" ...* particularly "*the potential hazard from the by-products of testing that floated back to earth in indiscriminate fashion, falling on rich and poor, strong and weak, Communist and non-Communist alike."*[194] Indian Prime Minister Nehru took up the cause for the third world, becoming the unofficial spokesperson for ending nuclear testing, asking very pointedly *"how can we be sure that our children may not go gradually blind or contract some internal disease."*[195]

The Decision not to Evacuate

The decision not to evacuate Rongelap, Rongerik, and Utirik for the Castle tests was made by the Commander in Chief of the Pacific Fleet (CINCPAC), Admiral Felix B. Stump. As Stump explained, *"The decision to evacuate Ujelang [during Ivy] was predicated not only on reducing health hazards to the indigenes to an acceptable minimum, but also to protect them from possible radiation hazards beyond the shadow of any adverse reflections on the U.S. government."* Since there were no adverse reflections, Stump ordered that *"No special efforts will be implemented by JTF-7 in support of ...evacuation of native populations."* [196] The decision not to evacuate also was the result of a "*policy of austerity in all phases of the operation dictated*

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[193] Neal O. Hines, *Proving Ground: An Account of the Radiobiological Studies in the Pacific, 1946-1961* (Seattle: University of Washington Press, 1962), 173.

[194] Robert A. Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960* (New York: Oxford University Press, 1978), viii.

[195] Quoted in Spencer R. Weart, *Nuclear Fear: A History of Images*, 199.

[196] Commander in Chief U.S. Pacific Fleet to Commander Joint Task Force SEVEN [sic], LANL Archives, 31 October 1953.

by recent reductions in fiscal year 1954 service budgets." Should any natives have to be evacuated, JTF-7 could use, with Stump's approval, ships assigned to the task force. In responding to a question about why the inhabited atolls were not temporarily evacuated for Bravo, Clarkson told Fields, *"The Natives were not evacuated because, on the basis of information available to us, it was not considered necessary and no significant fallout was expected on inhabited areas."*[197] Only one person, Los Alamos scientist, William Ogle, the Technical Director for Castle, worried about a radiological catastrophe, believing that it was simply luck that one had not happened already.[198]

Exposure Pathology

Human exposures to radioactive fallout occur by either or both external and internal pathways. External exposures occur when an individual comes into physical contact with radioactive particles. Internal exposures, of course, occur from eating and drinking contaminated food and water. The twenty-six military service personnel and two civilians stationed on Rongerik were protected from both pathways because they stayed indoors, wore full-length pants and long-sleeved shirts, and ate food stored in closed containers. Their minor exposures came from incidental contact with contaminated soil and vegetation as they walked between buildings. The men on Rongerik also were fortunate because they were not staring in the direction of Bikini when Bravo was ignited. Although about 120 miles from Bikini, Bravo's intense light could have caused flash blindness or eye burns. The potential for nuclear explosions to cause eye damage, known since the Trinity test in 1945, would later play a role in abandoning the Pacific Proving

[197] TWX, Clarkson to Fields, LANL Archives, October 5, 1954.

[198] Ogle, like his immediate superior, Graves, came to Los Alamos in 1944 and had played a small part in Trinity. He witnessed firsthand all of the Pacific tests, and his technical knowledge and testing experience were second to none, including that of Graves. Other than mentioning the possibility of a contamination disaster, he took no further action.

Ground as a nuclear test site. Even though rescue came thirty hours after Bravo exploded, the men of Rongerik were relatively unaffected. All returned to active duty, and no long-term studies of their health were conducted.[199] Ten sailors, securing helicopters on the Bairoko's flight deck, were exposed to fallout and received minor burns on unprotected areas, such as the backs of their necks. All ten sailors eventually returned to duty.[200]

By contrast, the islanders of Rongelap ingested contaminated food and water and walked, often barefooted, on contaminated soil until evacuated. Initial estimates calculated their contamination levels to be ten times more than the men on Rongerik.[201] A survey conducted of the Rongelapese on March 30th, reported that *"the necklace, scalp, [m]axillary and foot lesions observed and previously described in daily reports are believed to be due to radiation as a result of contamination with fallout material."*[202] The people of Utirik fared a bit better than their Rongelapese neighbors. Being further away from Bikini, they received less fallout. In addition, their water well was covered, thereby reducing internal exposures. The people of Utirik also benefitted from being evacuated on the ocean side of their atoll. Although the ocean swells and waves soaked every one during the evacuation, making their evacuation treacherous, the waves did wash off some of their external radiation. None of the Utirik people exhibited signs of radiation sickness and after a period of observation on Kwajalein Island, they were relocated to nearby Ebeye island until the conclusion of Castle. In the fall of 1954, they were allowed to return to their atoll.

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[199] TWX, From Health Division Leader Los Alamos Scientific Laboratory to CTG 7.1 Eniwetok, MI, LANL Archives, April 13, 1954.

[200] C. P. Carlson, LCDR, MC, USN: Memorandum from Bairoko to Task Force 7, *Information concerning investigations of burns on personnel of the USS Bairoko*, LANL Archives, March 22, 1954.

[201] TWX From the CTG 7.1 on the Estes to CTG 7.1 on Enewetok and TWX, From Health Division Leader Los Alamos Scientific Laboratory to CTG 7.1 Eniwetok, MI., April 13, 1954. LANL Archives.

[202] TWX from DMA to Bradbury, LANL Archives, March 30, 1954.

On March 5th, Clarkson flew to Kwajalein from his Enewetak headquarters to personally assess the situation of the evacuated islanders. Clarkson reported finding the Iroij of Utirik *"in good spirits [who] with great delight discussed his reactions to the light and bang."* When Clarkson asked John, the Iroij of Rongelap, what he felt after Bravo, John *"reached out and gave me a push."* A representative of the AEC's Division of Military Application, who accompanied Clarkson to Kwajalein, reported that the *"health situation of the natives is satisfactory … [and] there were no symptoms of radiation sickness."* The islanders expressed concern about their livestock and valuables and asked Clarkson *"when they could go they back to their islands."* Clarkson had no answers, telling them only that their atolls had to be surveyed and that they could not return until after the completion of test operations. After having his picture taken with a number of the natives, Clarkson returned to his headquarters convinced that the native situation had been dealt with appropriately."[203] Five days after his visit, Clarkson again reported on the condition of the Natives, saying:

> *Great efforts being made to keep natives comfortable on Kwaj. They are contented. Utirik group will be sent to nearby island Ebeye when High Commissioner [of the trust territory] directs and studied intermittently. Rongelap group retained Kwaj for intensive study by AEC/DOD research team. No decision as to time of return to home islands. Recommend wait until after series completed then recheck radiation levels again.*[204]

[203] Major General Percy Clarkson, *Memorandum for Record on Visit to Kwajalein, Friday, 5 March*, LANL Archives.

[204] TWX, Clarkson to Fields, March 10, 1954, LANL Archives.

Figure 31. Clarkson talking to Rongelap natives. LANL Archives.

However, the situation soon deteriorated. On March 13th, the first urinalysis report showed that the Rongelapese had suffered internal contamination from ingesting Iodine, Plutonium, Strontium, and Barium.[205] On March 15th, Bill Ogle told Bradbury that although no radiation burns had been reported, two adults and five children were experiencing hair loss. Physical examinations also found widespread impetigo among the children and pulmonary disease in the adults.[206] On March 19, Clarkson reported to the Chairman of the AEC that: *"two four Rongelap natives epilating [losing hair]. In areas of epoation [sic] unusually dry, pigmented, papular, scaling lesions are appearing in folds of neck and extending outwards."* He

[205] TWX, Thomas Shipman to CTG 7.1, On Eniwetok MI, LANL Archives, March 13, 1954.

[206] TWX, Ogle to Bradbury, LANL Archives, March 18, 1954.

concluded, oddly, that *"all natives are feeling well."*[207] The outward signs of exposure reached their peak at the beginning of April. A TWX message reported that while none of the Rongelapese showed signs of radiation sickness, *"[Thirty two] have shown varying degrees of epilation [sic]. Many have stopped epilating. Two of [eighteen] Ailinginae have shown slight epilation. Skin lesions involve scalp, forehead, neck, feet and toes. Three Rongelapese have lesions on one or more sites."*[208] Another TWX message said that the white cell counts continued very low and resembled chronic radiation sickness. However, as this same message revealed, the white cell counts were no longer dropping.[209] By April 5th, the skin lesions were *"definitely regressing."* Even though all of the Rongelapese were suffering from colds, there were no serious complications.[210] By April 12th, the health condition of the Rongelap people had stabilized, although white cell counts were slow in rebounding. Their homeland, however, would take much longer to heal. A survey party sent to Rongelap on April 14th found long-lived contamination and recommended that any *"return be delayed for at least one year."* At the request of Graves, the head of the health division at Los Alamos, Doctor Thomas Shipman, prepared a study, *"Project Hardy" (The Return of the Native),* to help determine when the Rongelap people could return to their atoll. A primary conclusion of the study was that *"it seems impossible that the natives can be returned to Rongelaap [sic] before September or October [1954] at the very earliest.* The Rongelap people did not return to their homes until 1957, and then only temporarily.[211]

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[207] TWX, CJTF Seven to Chairman USAEC Washington, LANL Archives, March 19, 1954.

[208] TWX, DMA to Bradbury, LANL Archives, March 30, 1954.

[209] TWX, CTG 7.1 to Bradbury, LANL Archives, April 1, 1954.

[210] TWX, CJTF 7 to Chairman AEC, LANL Archives, April 5, 1954.

[211] Shipman to Graves, LANL Archives, April 12, 1954; Shipman to Graves, LANL Archives April 13, 1957, and TWX, CTG 7.1 to Bradbury, LANL Archives, April 29, 1954.

Aftermath

No one, including Admiral Stump, General Clarkson, and Al Graves, was ever seriously questioned about their decision to detonate Bravo without first evacuating the nearby inhabited islands. Allowed to return to their atoll in 1957, the Rongelap people left again in 1985 because of continued fear about the long-term health effects of lingering radioactive contamination. The islanders of Utirik, the crew of the Lucky Dragon, and a small number of American servicemen also suffered, but to a much lesser extent than the people Rongelap. The net outcome of the failure to evacuate was to create a political awareness in the Marshallese and increase worldwide fear of radioactive fallout. The United States was put on notice that unfettered testing in the Marshall Islands was in jeopardy. The end would come four years later.

CHAPTER 9: SILENCE

Nuclear silence came to the Marshall Islands on August 18, 1958, not with the big bang of a thermonuclear test, but with a whimper that barely disturbed the ever-present seabirds. The test, codenamed Fig, had a yield of only 0.02 kilotons. Fig was the last scheduled test conducted as part of Operation Hardtack I. Although a test moratorium was on the horizon, the AEC assumed that testing in the Marshall Islands would eventually resume. Accordingly, the AEC initially kept Enewetak in a state of readiness, including making some improvements to facilities. However, political pressure applied by the Marshallese, world opinion, and the U.S. State Department made it clear that the islands would never again tremble under a nuclear detonation.[212] Bowing to the inevitable, The Pacific Proving Ground was formally "returned" to the Trust Territory in 1961. Another thirty years would elapse before the Marshall Islands gained independence.

Commodity Weapons

The final two test series carried out in the Marshall Islands, Redwing and Hardtack I, were, by and large, proof tests of commodity nuclear weapons being developed on demand for specific delivery systems.[213] The first indication that nuclear weapons were becoming commodity items came in October 1951 when Norris Bradbury told the DMA that *"being uncertain as to just which tactical employment (or employments) should have priority, [the military] has requested the development of practically every type of application conceivable."*[214] In 1953, the AEC and the DOD signed an agreement *"for the Development, Production, and*

[212] Bikini, before the moratorium, was abandoned because of its proximity to Rongelap.

[213] One example is the Redwing-Cherokee test, an airdrop of a production model thermonuclear weapon.

[214] Bradbury to Fields, LANL Archives, October 9, 1951. One such request was for a nuclear-tipped torpedo to destroy enemy submarines. The torpedo was built, but fortunately never used since it had a kill ratio of two – both the target and the boat that fired the torpedo.

Standardization of Atomic Weapons" that spelled out *"the responsibilities to be assumed by the AEC and the DOD respectively in connection with the determination of programs for proposed atomic weapons, their development, test, standardization, and production in accordance with military requirements."*[215] The Emergency Capability Program and Operation Castle completed the transformation, a fact noted by LASL mathematician Stan Ulam, the co-inventor of the hydrogen bomb, who said, in 1956, that *"One cannot help feeling that the field of weapon design is being exhausted and at least without a relatively new idea, there will be no big surprises."*[216] Ulam was correct.

Task Force Changes

Shortly after the conclusion of Castle, the Navy assumed executive responsibility for Redwing JTF.[217] The Chief of Naval Operations (CNO), Admiral Robert B. Carney, appointed Rear Admiral Charles (Swede) Momsen the Joint Task Force Commander.[218] The appointment, temporary since Momsen was scheduled to retire in a few months, had a moment of drama when, unexpectedly, the new JTF commander formally requested that *"criminal jurisdiction over civilians who lived and worked within the boundaries of in the Pacific Proving Ground be transferred to the military."* Momsen believed that the divided authority between the JTF and the Trust Territory created a serious problem *"concerning criminal jurisdiction.*" Momsen's request made no sense because major crime and espionage were nonexistent, as they had been since 1946. All civilians participating in the test program, had security clearances, were continually

[215] Atomic Energy Commission. *An Agreement Between the AEC and the DOD for the Development, Production, and Standardization of Atomic Weapons*, LANL Archives, March 21, 1953.

[216] Ulam to von Neumann, Los Alamos Theoretical Division Memo, T-841, LANL Archives, June, 20, 1956.

[217] Originally scheduled to manage Castle, the Navy deferred because it was carrying out a specialized underwater test, Wigwam, off the coast of San Diego.

[218] Momsen, a submariner, invented the "Momsen Lung" that allowed stranded submarine crews to safely evacuate a downed boat. Momsen also commanded the first United States submarine wolf pack during the war.

vetted by the AEC, and had never posed any criminal threat. And, of course, the Marshallese never caused problems.[219] Graves, told Momsen *"that such a concentration of executive, legislative, and judicial power is contrary to American principles, especially since there was no "serious inadequacies of the present jurisdictional arrangements."*[220] The Chief of Naval Operations let the issue die and Momsen retired, replaced by Rear Admiral B. Hall (Red) Hanlon.

In addition to a new executive agent, the JTF command structure was radically altered after Castle. The position of Scientific Director, a semi-autonomous role nearly equal in rank to the task force commander, was eliminated, replaced with the position of Deputy Task Force Commander for Scientific Matters, a position that reported directly to the JTF commander. Willian Ogle, a longtime Los Alamos physicist was appointed this position.[221] Operational units also were streamlined. All test activities were placed in one of seven task groups, each headed by a task group commander subordinate to the JTF commander. The Scientific Task Group (TG 7.1) co-located the competing work of Los Alamos and the UCRL under the command of Los Alamos physicist Galen Felt.[222] During Redwing, the UCRL questioned Felt's loyalty to the JTF

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[219] Momsen to the Chief of Naval Operations, *Criminal Jurisdiction over Civilians in the Pacific Proving Grounds, Trust Territory of the Pacific,* 8 December 1954; Ralph Carlisle Smith to Alvin Graves, *Criminal Jurisdiction over Civilians in the Pacific Proving Grounds, Trust Territory of the Pacific*, March 12, 1954; and Alvin Graves to Paul W. Spain, *Criminal Jurisdiction over Civilians in the Pacific Proving Grounds, Trust Territory of the Pacific*, March 15, 1954. LANL Archives.

[220] Ibid.

[221] The AEC made the task force commander its official representative. Pacific test operations were now controlled solely by a military commander.

[222] One of the underlying reasons for creating the UCRL was to stimulate the research and develop of thermonuclear weapons by creating, in the time-honored American tradition, a competitive environment. Not surprisingly, Bradbury opposed the UCRL's creation. As he told the DMA, *"in no research institution known to us is competition used as an incentive, because it is 'wasteful of research talent,' and would mean the insulation of one group from another resulting in duplication and overlap of efforts as well as the failure to cross-fertilize staff with new ideas and developments."* The competitive environment generated by the creation of the UCRL was not, as Bradbury had predicted beneficial. As a result of trying to differentiate itself from Los Alamos, the UCRL's first devices were costly failures, prompting verbal battles between LASL and UCRL staff.

when he made a series of personnel assignments that seemingly put UCRL personnel in inferior roles. Gerald Johnson, the senior UCRL scientist, lodged a protested with Felt, but with no success. Johnson elevated his protest to William Ogle, who did not take the situation seriously. It appeared to Johnson that Ogle, like Felt, favored Los Alamos. Johnson finally took his complaint to Herbert York, the director of the UCRL. York, hoping the matter could be resolved within the task force command structure, put the matter back in Felt's lap. Although Felt freely acknowledged the existence of *"extraordinarily diverse interests"* between Los Alamos and the UCRL, he nonetheless refused to give any credence to the UCRL complaint. This dust-up exacerbated already fractured relations between the two laboratories and led the UCRL to search for its own test site after the conclusion of Redwing.[223]

Although the primary purpose of Redwing was to proof test bombs and warheads for an emerging generation of weapon systems, an important secondary purpose was to explore methods of reducing fallout, as well as creating safety mechanisms to prevent unintentional detonations. When Bravo made fallout a worldwide issue, Los Alamos began exploring ways to reduce fallout from individual tests. One of those methods, "clean" bombs, was first explored during Redwing. Since most radioactive contamination, particularly ^{90}Sr and ^{137}Cs, comes from fission, Los Alamos developed versions of some thermonuclear devices that derived less energy from fission and more from fusion.[224] If fallout was reduced, Los Alamos reasoned, public concern about atmospheric testing might abate.[225] Although such tests produced marginally less

[223] Tension already existed between the two Labs prior to Redwing as a result of comments and actions by Edward Teller that Bradbury took exception with. After reading a **Life** magazine article highly laudatory of Teller, Bradbury sent a scathing, point-by-point rebuttal to United States Senator Clinton Anderson saying, in part, *"Much of the presently-appearing distortions of the technical history of the development of the thermonuclear weapon … appear to center around the personality of Edward Teller."*

[224] The use of the term "clean" was a misnomer. Clean devices only produced marginally less radioactivity.

[225] Los Alamos Theoretical Division, *T-1038: Long Range Fallout and Clean Weapons*, LANL Archives, July 8, 1950. The desire to convince the public that clean bombs worked as advertised also led the AEC to invite a delegation from the United Nations to observe and analyze the detonation of a clean device during the 1958

fallout, they did not alter public opinion. And, there was not a military use for bombs that were inherently bigger, heavier, and less energetic than their "dirty" versions.[226]

Table 6
Operation Redwing

Test Codename	Date	Laboratory	Atoll	Venue	Yield (kt)
Lacrosse	05/04/1956	LASL	Enewetak	Surface	40
Cherokee	05/20/1956	LASL	Bikini	Airdrop	3800
Zuni	05/27/1956	UCRL	Bikini	Surface	3500
Yuma	05/27/1956	UCRL	Enewetak	Tower	.190
Erie	05/30/1956	LASL	Enewetak	Tower	14.9
Seminole	06/06/1956	LASL	Enewetak	Surface	13.7
Flathead	06/11/1956	LASL	Bikini	Barge	365
Blackfoot	06/11/1956	LASL	Enewetak	Tower	8
Kickapoo	06/13/1956	UCRL	Enewetak	Tower	1.49
Osage	06/16/1956	LASL	Enewetak	Tower	1.7
Inca	06/24/1956	UCRL	Enewetak	Tower	15.2
Dakota	06/25/1956	LASL	Bikini	Barge	1100
Mohawk	07/02/1956	UCRL	Enewetak	Tower	360
Apache	07/08/1956	UCRL	Enewetak	Barge	1850
Navajo	07/10/1956	LASL	Bikini	Barge	4500
Tewa	07/20/1956	UCRL	Bikini	Barge	5000
Huron	07/21/1956	LASL	Enewetak	Tower	250

The need for enhanced safety mechanisms grew with the increasing numbers of weapons in the stockpile that made accidents more and more likely. Heretofore, stockpiled nuclear weapons were prevented from unintentional detonations by the physical separation of a bomb's nuclear material from its high explosives until a complete weapon was required. In some instances, AEC agents retained custody of nuclear material, even aboard bombers, until the

Hardtack I test series. Such analysis would show, it was thought, that American nuclear tests were not placing large amounts of radioactivity into the atmosphere. Planning for this test, known unofficially as the United Nations Observer Shot, was well advanced before both Los Alamos and the Department of Defense forced its cancellation by arguing that allowing scientists from other countries to analyze bomb debris was tantamount to giving away American nuclear secrets. *Clean Bombs for UN Observers*, LANL Archives, April 1, 1958 and *Handbook for UN Observers*, LANL Archives, 1958.

[226] Los Alamos Theoretical Division, *T-1038: Long Range Fallout and Clean Weapons*, LANL Archives, July 8, 1950.

material was placed inside the bomb casing, a laborious process known as in-flight insertion. When technical advances in weapon design did away with in-flight insertion, built-in safety mechanisms were needed. These mechanisms proved their worth when an Air Force B-36, on a routine flight, lost its thermonuclear bomb when the shackle holding the device broke. The bomb crashed through the bomb bay doors and broke into pieces on impact with ground, but did not explode.[227] The safety mechanisms first tested during Redwing, and later Hardtack, also proved their worth when four thermonuclear weapons fell on Palomares, Spain, after a mid-air collision between a B-52 bomber and an aerial tanker. Three of the weapons fell on the tomato fields of Palomares and one into the Atlantic. None of the bombs exploded, although the United States had to buy the region's entire tomato crop when one of the bombs broke apart on impact and contaminated the surrounding area.[228] Another more chilling example of the value of safety mechanisms occurred when exploding rocket fuel punched an intercontinental missile with a thermonuclear warhead out of its silo - through a twenty-ton door.[229] Although heavily damaged by the explosion and fire, the warhead did not detonate.[230]

[227] This accident occurred just south of Albuquerque, New Mexico. Decades later, pieces of the bomb casing continued to be found.

[228] Flora Lewis, *One of our H Bombs is Missing* (New York: McGraw-Hill, 1967).

[229] A technician dropped a socket, which ricocheted off the silo wall puncturing the rockets thin skin releasing fuel and oxidizer that an electrical spark subsequently ignited.

[230] Schlosser, Eric Matthew. *Command and Control: Nuclear Weapons, the Damascus Accident, and the Illusion of Safety.* New York, Penguin Press, 2013. Another safety mechanism, the Permissive Action Link (PAL) was developed later to thwart an enemy from purposefully detonating a nuclear bomb.

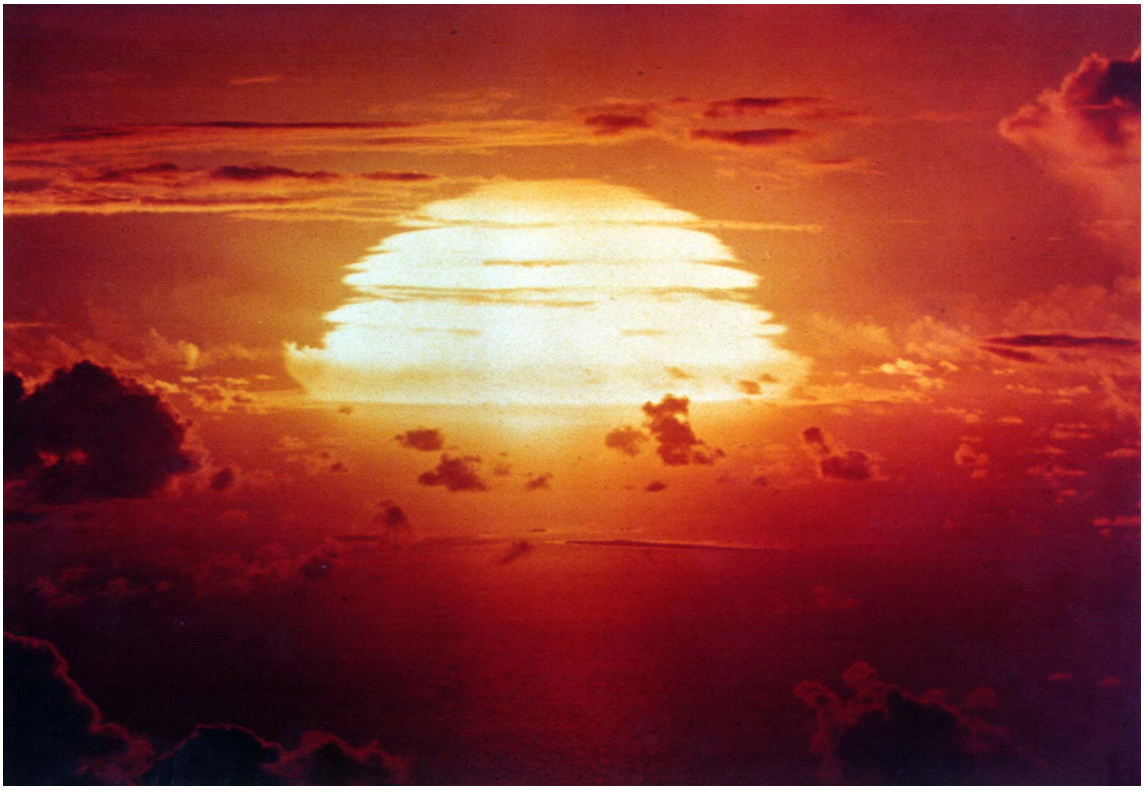

Figure 32. Test Apache, a barge shot at Enewetak. LANL Archives.

Figure 33. Lacrosse Device with Line-of-Sight Pipes. LANL Archives.

Figure 34. Aerial view of Lacrosse set-up on Runit reef. LANL Archives.

Figure 35. Seminole. LANL Archives.

Taongi Atoll

The dustup between Felt and Johnson led the UCRL to search for a test site of its own, beginning with a survey of the area north of the Brooks Range and east of Point Barrow, Alaska. The search came to nothing because the nominal weather conditions proved too extreme.[231] The UCRL also investigated the use of Taongi, the most remote of all the Marshallese atolls.[232] Located nearly 300 miles north and east of Bikini, Taongi was, for a short time early in World War II, a very small Japanese wartime seaplane base and weather station. Too remote to be of

[231] Herbert York to K. E. Fields, LANL Archives, November 9, 1954. Later, despite weather extremes, Amchitka Island was used for three nuclear tests: Longshot (1965), Milrow (1969), and Cannikin (1971).

[232] Taongi is now known as Bokak Atoll.

military value, the atoll was abandoned by the Japanese Navy in early 1943.[233] Taongi was not a complete unknown. It had been briefly considered for Operation Castle but dismissed because of its small land area. The UCRL, however, believed that the atoll's remote location and prevailing wind patterns were nearly ideal and its lack of real estate could be compensated for.

The UCRL quest dovetailed with an ongoing effort by the DMA to find a new off-continent test site. The introduction of high-altitude testing, with its potential for causing flash blindness, brought the utility of both Enewetak and Bikini into question. At the direction of the DMA, the Joint Task Force investigated the Tristan da Cunha group of islands located in the South Atlantic as well as a number of islands in the Pacific including Malden and Starbuck. The Tristan da Cunha group was ruled out because of *"unfavorable or topographic reasons."* The islands also were populated and under the control of Great Britain. Malden and Starbuck islands also were ruled out for similar reasons.[234] The upshot of these investigations was that the JTF could not find a geographical location sufficiently better than the Marshall Islands to warrant development of another remote test site. Consequently, both the AEC and the JTF supported the UCRL's investigation of Taongi particularly since the scheduled repatriation of the Rongelapese could hinder the upcoming Hardtack test series. The close proximity of Rongelap to Bikini raised the specter of flash blindness and eye burns. The only possible way to prevent eye burns was to make sure the Rongelapese *"were gathered together and faced away from the target area at shot time."* Coordinating such an activity was nearly impossible if, for no other reason, then zero

[233] http://en.wikipedia.org/wiki/Bokak_Atoll.

[234] C. B. Momsen to the Chairman of the Atomic Energy Commission, LANL Archives, May 3, 1955.

times were often delayed.[235] If Rongelap was resettled, the AEC might impose *"severe limitations on future use of Bikini, including a cap on the energy yield of test devices"*[236]

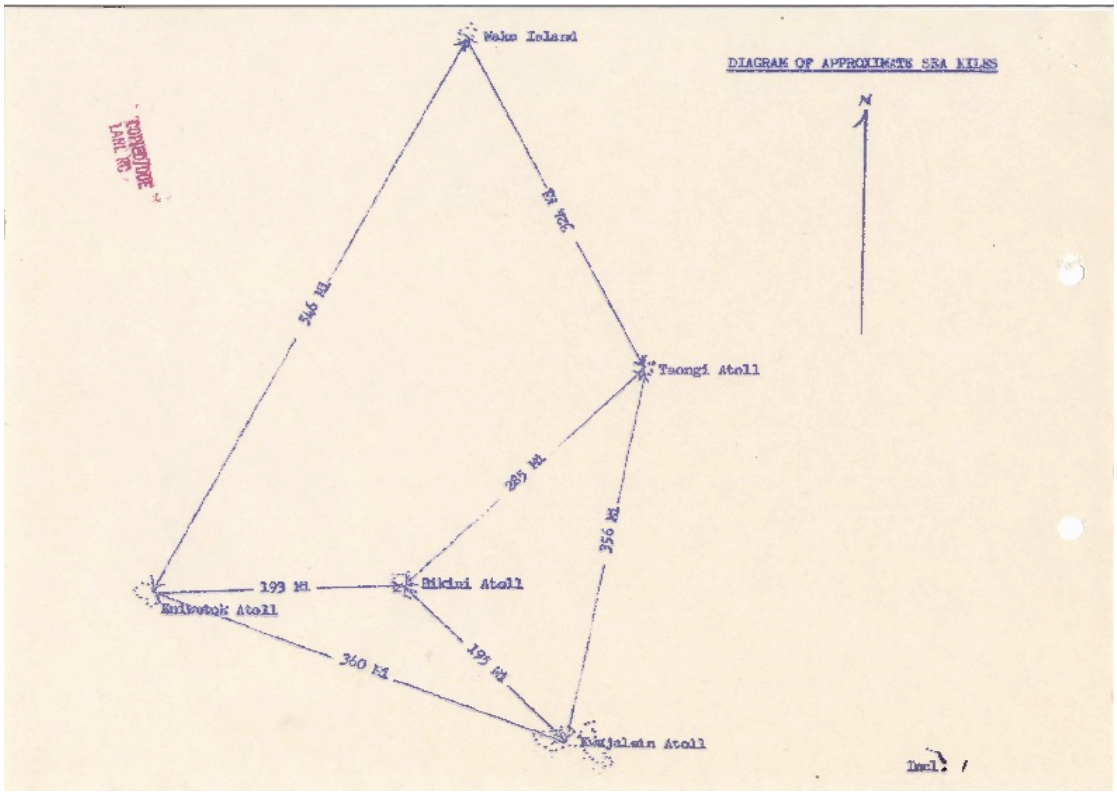

Figure 36. Taongi Sea Chart. LANL Archives.

On paper, Taongi's remote location and wind pattern appeared ideal. Fallout from a test would travel more than a thousand miles over an empty ocean before making landfall. And, since as many as thirty tests were being considered for Hardtack, a third test site offered the means of

[235] TWX, DCTG 7.1 Eniwetok MI to CTG Los Alamos NMEX, March 6, 1958; and TWX, CTG 7.1 Los Alamos Nmex to CTG 7.1 Eniwetok MI, March 7, 1958, LANL Archives.

[236] Galen Felt to Alvin Graves, *Staff Study on the use of Taongi Atoll*, LANL Archives, February 1957; W. E. Ogle to A. C. Graves, *Present Outlook for the Redwing Operation*, LANL Archives, April 2, 1955; and TWX, Gerald Johnson to Alvin Graves, LANL Archives, February 15, 1957. The UCRL also was planning to use Taongi for a 40 megaton test.

conducting such a large number of tests in the shortest possible time.[237] Accordingly, the AEC authorized surveys of the atoll by both the Scripps Institute and the United States Navy. These surveys found a shallow entry channel, a shallow lagoon, and very little land area. The UCRL did not consider these problems insurmountable. The problem of the shallow access channel could be overcome, in the short run, by operating aboard ships in the open ocean around Taongi. While somewhat difficult, the technology existed to do so. The UCRL further proposed successive underwater tests to excavate both the entry channel and lagoon. However, Taongi was not used for Hardtack I because of budget restrictions and a looming test moratorium.

Anticipating a moratorium, Los Alamos and the UCRL submitted requests to the DMA for more than thirty tests. The DMA thought the number excessive and, instead, gave tentative approval for twenty tests evenly divided between the two laboratories.[238] Bradbury immediately protested, noting that since Los Alamos was responsible for six new weapons and the UCRL only three, an even split of tests hampered the ability of Los Alamos to meet its *"immediate and definite responsibilities."*[239] What that meant, Bradbury said, is that *"our program with one or two exceptions, are nose-to-the-grindstone programmatic experiments related to things we have to do with specific weapon designs; they are having fun."*[240] With a moratorium more and more likely, the DMA relented and secured presidential permission for thirty-five tests divided approximately nearly evenly between the two laboratories - seventeen for Los Alamos and fifteen for the UCRL

[237] L. Sherman to A. C. Graves, *The Use of Taongi*, LANL Archives, November 1, 1956.
[238] TWX, Starbird to Bradbury and York, LANL Archives, February 13, 1957.

[239] Each proposed weapon required multiple tests to fully certify it for the stockpile.

[240] TWX, Bradbury to Starbird, LANL Archives, February 20, 1957.

Table 7 Operation Hardtack I					
Test Codename	**Date**	**Laboratory**	**Atoll**	**Venue**	**Yield (kt)**
Cactus	05/05/1958	LASL	Enewetak	Surface	18
Fir	05/11/1958	UCRL	Bikini	Barge	1360
Butternut	05/11/1958	LASL	Enewetak	Barge	81
Koa	05/12/1958	LASL	Enewetak	Surface	1370
Wahoo	05/16/1958	LASL	Enewetak	Underwater	9
Holly	05/20/1958	LASL	Enewetak	Barge	5.9
Nutmeg	05/21/1958	UCRL	Bikini	Barge	25.1
Yellowwood	05/26/1958	LASL	Enewetak	Barge	330
Magnolia	05/26/1958	LASL	Enewetak	Barge	57
Tobacco	05/30/1958	LASL	Enewetak	Barge	11.6
Sycamore	05/31/1958	UCRL	Bikini	Barge	92
Rose	06/02/1958	LASL	Enewetak	Barge	15
Umbrella	06/08/1958	LASL	Enewetak	Underwater	8
Maple	06/10/1958	UCRL	Bikini	Barge	213
Aspen	06/14/1958	UCRL	Bikini	Barge	319
Walnut	06/14/1958	LASL	Enewetak	Barge	1450
Linden	06/18/1958	LASL	Enewetak	Barge	11
Redwood	06/27/1958	UCRL	Bikini	Barge	412
Elder	06/27/1958	LASL	Enewetak	Barge	880
Oak	06/28/1958	LASL	Enewetak	Barge	8.9
Hickory	06/29/1958	UCRL	Bikini	Barge	14
Sequoia	07/01/1958	LASL	Enewetak	Barge	5.2
Cedar	07/02/1958	UCRL	Bikini	Barge	220
Dogwood	07/05/1958	LASL	Enewetak	Barge	397
Poplar	07/12/1958	UCRL	Bikini	Barge	9300
Scaevola	07/14/1958	LASL	Enewetak	Barge	0
Pisonia	07/17/1958	LASL	Enewetak	Barge	255
Juniper	07/22/1958	UCRL	Bikini	Barge	65
Olive	07/22/1958	UCRL	Enewetak	Barge	202
Pine	07/26/1958	UCRL	Enewetak	Barge	2000
Quince	08/06/1958	UCRL	Enewetak	Surface	0
Fig	08/18/1958	UCRL	Enewetak	Surface	.020

Like Redwing, the Hardtack tests were conducted rapidly, with multiple shots fired on four occasions. Thirty-two of the thirty-five tests were conducted in the Marshall Islands. Los Alamos conducted all of its tests on Enewetak. The UCRL used both Bikini and Enewetak.[241]

[241] Felt, the Los Alamos protagonist at Redwing, resigned as Commander of JTF 7.1 to take a job in Massachusetts. Felt was replaced by Don B. Shuster of the Sandia Corporation, the organization that provided engineering services to both Los Alamos and the UCRL As a Sandia employee, Shuster was a neutral entity. Jerry Johnson, the UCRL protagonist, was relegated to the sidelines when he was assigned to plan the United Nations Observer shot. These changes blunted the conflict and allowed Hardtack to be carried out without incident.

Two shots, Wahoo and Umbrella, were fired underwater.[242] The UCRL fired the highest yield shot, Poplar, on a barge in Bikini's lagoon. One test, Cactus, created a crater on Runit Island that was later used as the dump site for the 1970s cleanup of Enewetak. Contaminated soil and test detritus were dumped in the Cactus crater and covered with a massive concrete dome. The dome is a constant reminder of the long-term environmental issues created by nuclear weapons testing.

Shot Juniper, fired by the UCRL on July 22, 1958, was the last nuclear test conducted at Bikini; Shot Fig, conducted at Enewetak, followed on August 18th. Two days after Fig, President Dwight Eisenhower wrote to Bradbury saying, *"I am today announcing that the United States will suspend nuclear weapons tests for a period of twelve months and, under certain conditions of progress toward real disarmament, continue that suspension on a year-to-year basis."*[243] Although it was not known at the time, nuclear testing in the Marshall Islands had come to end.

Moratorium

Calls for a suspension of testing had been increasing since Bravo. Japan was the first nation to protest, followed by the Marshallese, and then by India, the acknowledged leader of the unaligned nations. Japan reacted viscerally to the contamination of the Lucky Dragon and temporary collapse of its tuna market. The Marshallese, surprisingly, because of their natural reticence, complained to the United Nations that, *"its people on two small coral islands suffered ill effects from nuclear tests in March."* The Indian government took up the Marshallese cause, arguing before the United Nations that the United States did not have the right to use the Marshall Islands for nuclear testing *"in the same way as New Mexico."*[244] Indian involvement

[242] Only five tests were ever conducted underwater.

[243] President Dwight Eisenhower to Norris Bradbury, August 22, 1958; John McCone to Norris Bradbury, August 29, 1958; and Norris Bradbury to President Dwight Eisenhower, September 18, 1958. LANL Archives.

[244] *New York Times*, July 9, 1954.

ultimately led to the Bandung Conference of 1962 and the creation of the non-aligned countries movement.

Because Bravo made fallout an international issue, Secretary of State John Foster Dulles asked the AEC to comment on the ramifications of a possible test moratorium. The AEC, in turn, forwarded Dulles' request to Los Alamos and the UCRL. The two laboratory directors, Norris Bradbury and Edward Teller, responded saying that our *"technical advice is, in the main, negative."* A moratorium on testing, particularly one of long duration, would freeze the current state of knowledge. This would mean Los Alamos and the UCRL would, in all likelihood, wither as scientific institutions as their scientific staff sought challenging work elsewhere. The question, then, was who would take care of the stockpile and insure its safety and vitality. The second problem that worried Bradbury and Teller was the absence of any technical means of monitoring Soviet compliance, since, as they noted, *"Long range detection is insufficient to give a measurement of the size of any explosion."* By keeping energy yields low, the Soviets could effectively hide nuclear tests and advance their weapons program. Bradbury and Teller believed that *"any agreement would be rigorously observed by ourselves whereas it might be circumvented or at an appropriate moment openly violated by Russia."*[245]

Missing from the Bradbury and Teller analysis was any mention of fallout. Those scientists who worked with nuclear weapons, particularly Teller, did not worry about fallout. Their scientific understanding of radiation led them to believe that testing did not produce anywhere near the amount of contaminated debris needed to harm humans on a global scale. Bradbury and Teller erroneously believed that a moratorium could be averted and public anxiety about fallout allayed by restricting the energy yields of tests. Their hope was to continue testing

[245] Edward Teller and Norris Bradbury, *Memorandum for the General Manager, USAEC*, LANL Archives, June 11, 1954.

low-yield devices, which would allow both laboratories to continue developing tactical weapons for the military.[246] But their hopes and beliefs were unrealistic, even naïve in their understanding of public opinion.

As the moratorium approached, Acting AEC Chairman W.F. Libby suggested that both laboratories undertake a program to analyze the massive amount of data gathered during Hardtack I. Such work, he hoped, would keep both Los Alamos and the UCRL viable for a year or two. Libby further suggested that Bradbury make plans to reorganize Los Alamos to keep the Laboratory in *"the best scientific trim"* during the moratorium by promoting pure research and inventing activities to keep the scientific staff engaged. Libby further suggested that Bradbury do his planning in secret to *"prevent there developing ... a feeling that you, and we, believe a moratorium or cessation is immediate."* Apparently, Libby thought that Los Alamos scientists did not keep up with world affairs.[247] The President told Bradbury, it *"will be necessary that we maintain our weapons development progress during the period and with no less urgency than in the past."* John McCone, the newly installed Chairman of the AEC, added the caveat that Bradbury *"should keep in mind the uncertainty as to whether the Soviets Union will fulfill the conditions that the President has set forth as prerequisite for continuation of the moratorium."*[248] Nothing much came of these admonitions. On October 30th, the UCRL detonated a very low-yield device codenamed Titania, whose whimper signaled the beginning of the moratorium.

Although both Norris Bradbury and Teller thought the moratorium would be deleterious to their labs, the ultimate effect was minimal. Los Alamos turned its expertise to the design of

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[246] Ibid.

[247] United States Atomic Energy Commission and United States Department of Defense*, Press Release*, LANL Archives, August 29, 1958.

[248] President Dwight Eisenhower to Norris Bradbury, August 22, 1958; John McCone to Norris Bradbury, August 29, 1958; and Norris Bradbury to President Dwight Eisenhower, September 18, 1958. LANL Archives.

nuclear reactors for interstellar rockets in a program called Project Rover. The lab also explored the use of nuclear explosions in an early form of fracking. The huge amount of data generated by the Hardtack tests was largely unused. When testing resumed in 1961, Los Alamos picked up where it had left off, but not in the Marshall Islands.

EPILOG

On a bright January morning in 1999, an Air Marshall Islands passenger plane buzzed the runway that runs the length of Enewetak Island. Built in 1953 for the Castle test series, the runway is still operational, used by Air Marshall Islands flights that serve Enewetak. Most days, however, the runway serves as the only paved road on the island. Buzzing the runway not only signaled the plane's arrival but, more importantly, chased away a small herd of free roaming pigs.

Figure 37. Enewetak Welcome Sign. Author's Collection.

On the plane was a group of men, mostly from Los Alamos, who had participated in the Pacific test operations. Both the DOE and the Laboratory had arranged for them, in the twilight of their lives, to visit Enewetak and Bikini. Two of the men, Jack Clark and Darol Froman, had participated in the 1948 Sandstone operation. It was Clark who had complained about the delay

in relocating the Enewetak peoples to Ujelang. Also in the group with Clark were Herb Grier and Galen Felt. These three had been trapped by Bravo's fallout in the firing bunker in 1954. Norris Bradbury, the long-time director of Los Alamos, completed the group of Pacific veterans.

Figure 38. From left to right: Herb Grier, Jack Clark, and Galen Felt in Bravo Firing Bunker. Author's Collection

Figure 39. Norris Bradbury. Author's collection.

Three Marshallese women met the plane, decorating each passenger with a colorful lei. Small Japanese-made pickup trucks belonging to a local construction crew took the passengers to the dormitory and mobile homes reserved for visitors. Although Enewetak Island was home to 900 islanders, very few were visible on the ride to the dormitory. Not until the showing of videos in the outdoor common area did a large group of natives appear. Gifts of cartoon videos made the island's children constant companions.[249]

[249] Videos were prized possessions because there was no television service on Enewetak.

Figure 40. Enewetak Governing Council. Author's Collection.

The group made several trips to the northern ground zero islands by way of small Boston Whaler sport fishing boats. Cactus Crater, on Runit Island, was reached after bushwhacking through the thick brush that covers the island. During the 1970s cleanup of the northern islands, contaminated soil and detritus was dumped into the crater, which was then capped with a concrete dome. Mike's underwater crater was spectacular. It was, as the helicopter observers saw in 1951, a distinctive deep blue, which contrasted sharply with the green shallow water of the surrounding lagoon. The Seminole crater on Bogin, resembled a small lake populated by a species of small, but very aggressive sharks.

Figure 41. Aerial view of the Cactus Dome and Lacrosse Crater. Author's Collection.

Figure 42. Aerial View of Mike Crater. Author's Collection.

From Enewetak, the group flew to Bikini Atoll, landing on Enyu Island. Because Enyu's shoreline is extremely rocky, everyone had to wade into the lagoon's rough surf to board the transport boats. Fortunately, at Bikini Island, the boats were pulled on shore by a small bulldozer. At Bikini, Clark, Grier, and Felt were able to enter the timing and firing bunker that had protected them from the worst of Bravo's fallout. Somewhat surprisingly, none of them showed any emotion. The only person to show any emotion during the trip was Bradbury, who

recalled on more than one occasion, the tremendous burdens he shouldered for Los Alamos as the Laboratory carried out its work. Despite repeated promptings, none of the men said much about their experiences. For them, nuclear testing was a distant memory. When they passed away over the next several years, so too did the last living connections between Los Alamos and the Marshall Islands. The only visible reminder in Los Alamos are two street signs: *Bikini Atoll Road* and *Enewetak Atoll Road*. Few at Los Alamos even know the meanings of the names.

Figure 43. Airport terminal at Bikini. Bikini. Ejit, and Kili are the islands on which most Bikinians now live. Author's Collection.

Figure 44. Wading into the surf at Enyu Island. Author's collection.

The New World

The New World came of age in the Marshall Islands. The crude fission bombs of World War II were improved and perfected, particularly by Operation Sandstone in 1948. Thermonuclear weapons became a reality after Operation Castle in 1954. Operations Redwing and Hardtack provided the military with custom weapons and, at the same time, advanced the technology of nuclear safety. The New World, however, was not without its problems, particularly the ever-present radioactivity. When Trinity's radioactive debris contaminated the grain fields of the Midwest, the response was to move testing to the Marshall Islands, where the seemingly empty ocean that would swallow any radioactive fallout. This scheme worked until Bravo demonstrated that the world was not big enough to hide the radioactive fallout from thermonuclear detonations. Fear of radioactive fallout led to the 1958 test moratorium.

When the last nuclear detonation was conducted on Bikini (the Juniper test of July 22, 1958), the AEC knew that the atoll could never again be used for nuclear testing. Lingering radiation had rendered all but two of Bikini's islands unusable. More significantly, the atoll's proximity to Rongelap and the likelihood of eye burns from thermonuclear tests rendered any further use of the atoll politically untenable. A cleanup of Bikini during the 1960s led to the temporary return of a few families in the early 1970s. The cleanup, however, could not remove all of the ^{137}Cs and ^{90}Sr, which migrated to the plant stocks that were the staple of the Bikinians' diet. After just a few years of living on Bikini, the returnees had accumulated significant body burdens of these isotopes and were returned to Kili. In 1980 the Department of Energy published a pamphlet, "*The Meaning of Radiation at Bikini Atoll*," in an attempt to explain why the Bikinians could not live on their homeland.[250] The pamphlet offered no hope that the atoll could ever be reoccupied, and Bikini remains, today, uninhabited and uninhabitable.

When the moratorium began, Enewetak Atoll was kept in a state of readiness under the codename Project Switch. A small work crew was stationed on the atoll to maintain the extensive facilities and construct a balloon factory on Engebi Island.[251] Tethered balloons, successfully and widely used at the Nevada Test Site in place of towers, were going to replace barges. As the moratorium wore on, however, Enewetak became an albatross as the costs of maintaining the atoll in a state of readiness grew. The atoll was officially abandoned as a test site in early 1961. A 1970s cleanup permitted the return of some of the atoll's people, who resettled principally on the island of Enewetak, located in the southern half of the atoll. The northern half of the atoll, its islands used as ground zero sites, remained heavily contaminated. Despite the massive cleanup effort, the northern islands remain contaminated and uninhabitable. Engebi and Runit islands

[250] United States Department of Energy, *The Meaning of Radiation at Bikini Atoll*, 1980.

[251] The facility was never built.

have the distinction of being the most bombed real estate in the world. The DOE published a second pamphlet, "*The Enewetak Atoll Today*"[252] to explain the effects of radioactive contamination and why part of the atoll will likely remain uninhabitable.

The Rongelap people have disappeared from view, although they were the only Marshallese to be physically harmed by a United States nuclear test.[253] Radioactive contamination, particularly that of ^{137}Cs, prevented the Rongelap people from being returned to their homes until 1957. Repatriated, the Rongelapese witnessed the many tests of Operation Hardtack I with unease. In 1985 the islanders, fearing lingering radiation, left Rongelap with the assistance of Greenpeace, moving to an uninhabited island of Kwajalein Atoll, where they remain today. There is no timetable for their return.

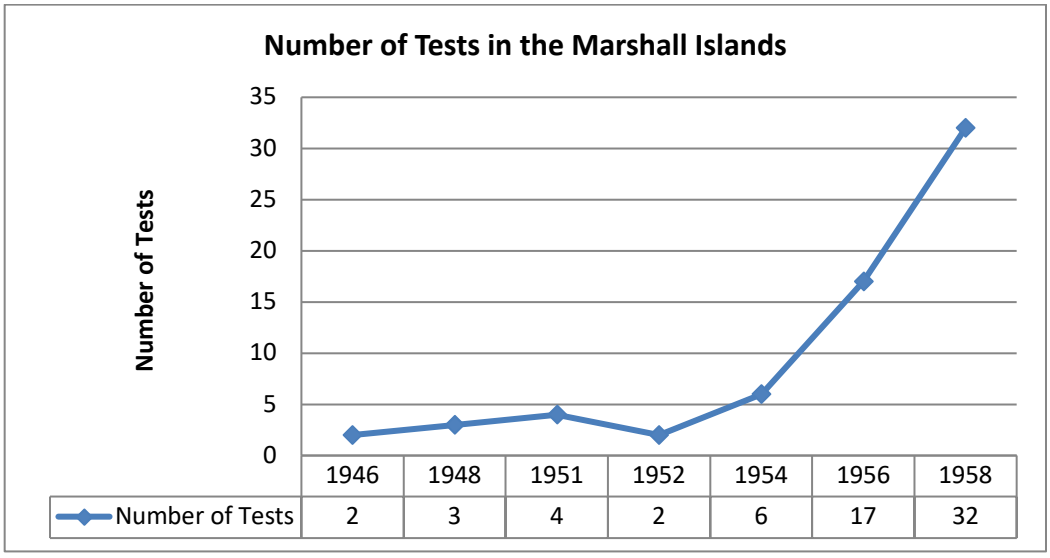

Figure 45. Number of tests in the Marshall Islands by year.

[252] United States Department of Energy, *The Enewetak Atoll Today*, 1979.

[253] E. Lessard, R. Miltenberger, R. Conard. S. Musolino, J. Naidu, A. Moorthy, and C. Schopfer, *Thyroid Absorbed Doses for People at Rongelap, Utirik, and Sifo on March 1, 1954*, xiii.

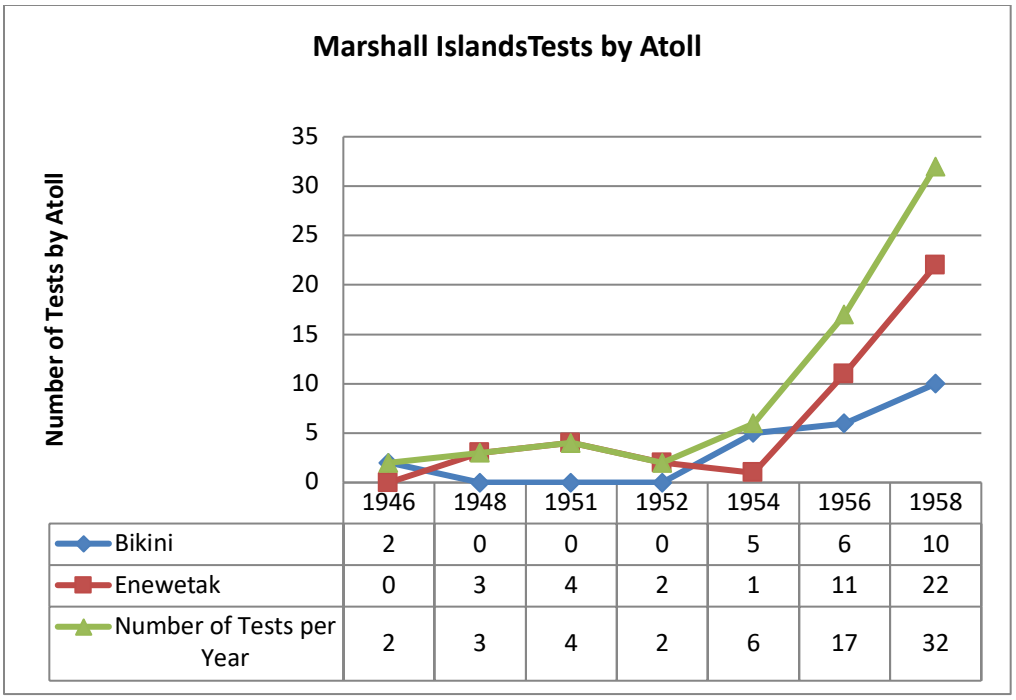

Figure 46. Marshall Islands Tests by Atoll.

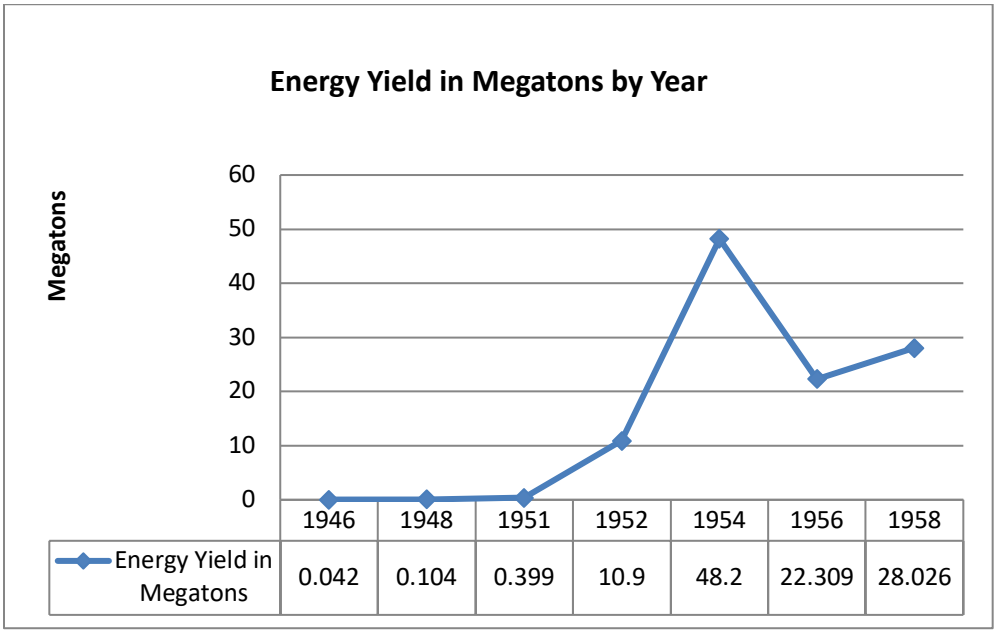

Figure 47. Energy Yields by Year.

Fifty-seven years after the last nuclear test was conducted in the Marshall Islands, Bikini Atoll remains uninhabited. The Bikini people, removed from their homeland in 1946 for the Crossroads tests, constitute a modern-day Diaspora living in enclaves on Kili and Ejit Islands and even in the United States. The Enewetak people, relocated to nearby Ujelang Atoll prior to the Sandstone test series in 1948, constitute a second, albeit smaller, Diaspora. More fortunate than their Bikini counterparts, some of the Enewetak people have been able to return to part of their homeland. However, many of their individual islands are not likely to be resettled. And, because of the manner in which the Navy managed the 1948 relocation, the identities of two ancestral tribes of Enewetak has been all but obliterated.[254]

In 1994, after rediscovering that twelve Americans had been injected with plutonium during the course of medical treatment in the 1940s and 1950s, Secretary of Energy Hazel O'Leary inaugurated an openness initiative to investigate all instances of exposures to radiation, including those that occurred in the Marshall Islands.[255] In July, Tony deBrum, a senator in the Marshallese parliament submitted testimony about the effects of nuclear testing on the Marshallese to the Commission on Human Radiation Experimentation. Senator deBrum, a native of Likiep Atoll, witnessed a number of nuclear tests, was involved in the rehabilitation of Bikini, assisted in the resettlement of the atoll, as well as its subsequent re-evacuation. deBrum's testimony had one overarching theme: The United States had used the Marshallese, particularly the people of Rongelap, Utirik, and Ailuk Atolls, as *"subjects of human radiation*

[254] The most recent research on the contamination of these atolls is contained in *Health Physics, No. 73*. Rongerik, also heavily contaminated, is normally unpopulated. A small contingent of U.S. servicemen temporarily stationed there to operate a weather station during Operation Castle, were exposed to fallout as well.

[255] Eileen Welsome, *The Plutonium Files: America's Secret Medical Experiments in the Cold War* (New York: The Dial Press, 1999) and President's Advisory Committee. *Final Report of the Advisory Committee on Human Radiation Experiment* (New York: Oxford University Press, 1996).

experiments."[256] deBrum's testimony underscored the lack of a satisfactory explanation about why Rongelap, Utirik, and other inhabited atolls had not been evacuated prior to Bravo and why no one was held accountable. His testimony also highlighted the fact that the Marshallese were never accorded, as the United Nations trusteeship stipulated, protection equal to that of United States citizens. Nuclear testing clearly placed many Marshallese in harm's way. The Marshallese petition to end testing, sent to the United Nations in 1954, was effectively quashed by the U.S Finally, deBrum's testimony highlighted the differences in the memory of nuclear testing between those who tested atomic bombs and those who bore the burden of those tests.[257] For the Marshallese, the memory persists. For Los Alamos, it is non-existent.

Were the Marshallese people, as deBrum charged, guinea pigs, purposely exposed to the radioactive fallout from atomic bombs? The President's Advisory Committee on Human Radiation Experiments, established in the early 1990s to investigate such charges, found no such evidence and concluded that the exposure of the Rongelap people, and by extension that of all the Marshallese, was an accident. The known evidence supports this finding. The explosive yields of Bravo and four other Castle test devices, were significantly underestimated. Weather forecasters consistently miscalculated both wind and fallout vectors. Most significantly, everyone involved with Bravo believed the unproved theory of stratospheric trapping. The budgetary constraints cited by Admiral Stump also contributed to harming the people of Rongelap. Although the President's Advisory Committee was technically correct in concluding that the Marshallese people were not guinea pigs, but rather innocent victims, the question that remains, then, is whether or not knowing about the possibility of widespread fallout constitute

[256] Tony deBrum, *Statement of the Republic of the Marshall Islands before the Commission on Human Radiation Experimentation*, LANL Archives, July 5, 1994.

[257] President's Advisory Committee. *Final Report of the Advisory Committee on Human Radiation Experiment* (New York: Oxford University Press, 1996), 376-377.

human experimentation? Again, the answer is technically no since the exposures were not planned but accepted as a cost of doing business. However, the fact remains that with the exception of a few Americans, only the Marshallese, as a group of people, were put in harm's way.

The Advisory Committee did fault the medical care given to Rongelap people. A lack of concern for cultural and linguistic differences affected the quality of medical care. Like the issue of human experimentation, the analysis of this finding is difficult to state with certainty. The medical care given to the Rongelapese was appropriate, but not very helpful since there is not a medical cure for radiation exposures. The body is either to heal itself through cell regeneration, or not. The health status of exposed individuals was tracked through blood and urine samples. Antibiotics were used to treat and prevent infections in those cases where immune systems had been compromised. However, in treating the Rongelap people, medical personnel did not, and perhaps could not, tell the people what was happening, or why, as the only population significantly harmed by radioactivity, they were being observed and studied. Nor, were the islanders told about possible long-term consequences to their health.

In the United States, including Los Alamos, there is almost no memory of testing in the Marshall Islands. Bikini is more famous for the swimsuit than the site of forty-three nuclear detonations. Those who work in the Laboratory's administration building walk past murals and exhibits of Laboratory achievements that make no mention of nuclear testing. For the Marshallese, the memory of testing is immediate and ever present. Each morning, the people of Bikini and Rongelap wake up in places far from their ancestral homes. So too, do half of the Enewetak people. If these people are ever able to return home, then perhaps, as the Iroij of Utirik said in 1954, *"The world, we think she start over again."*[258]

[258] *Report of Evacuation of Natives, Utirik Atoll, 4 March 1954*, LANL Archives.